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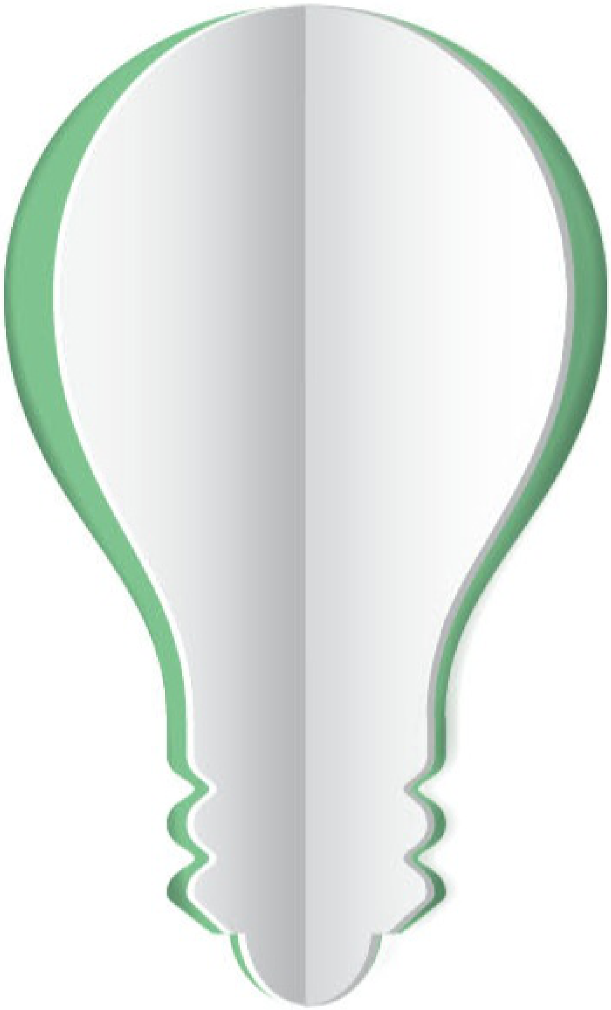

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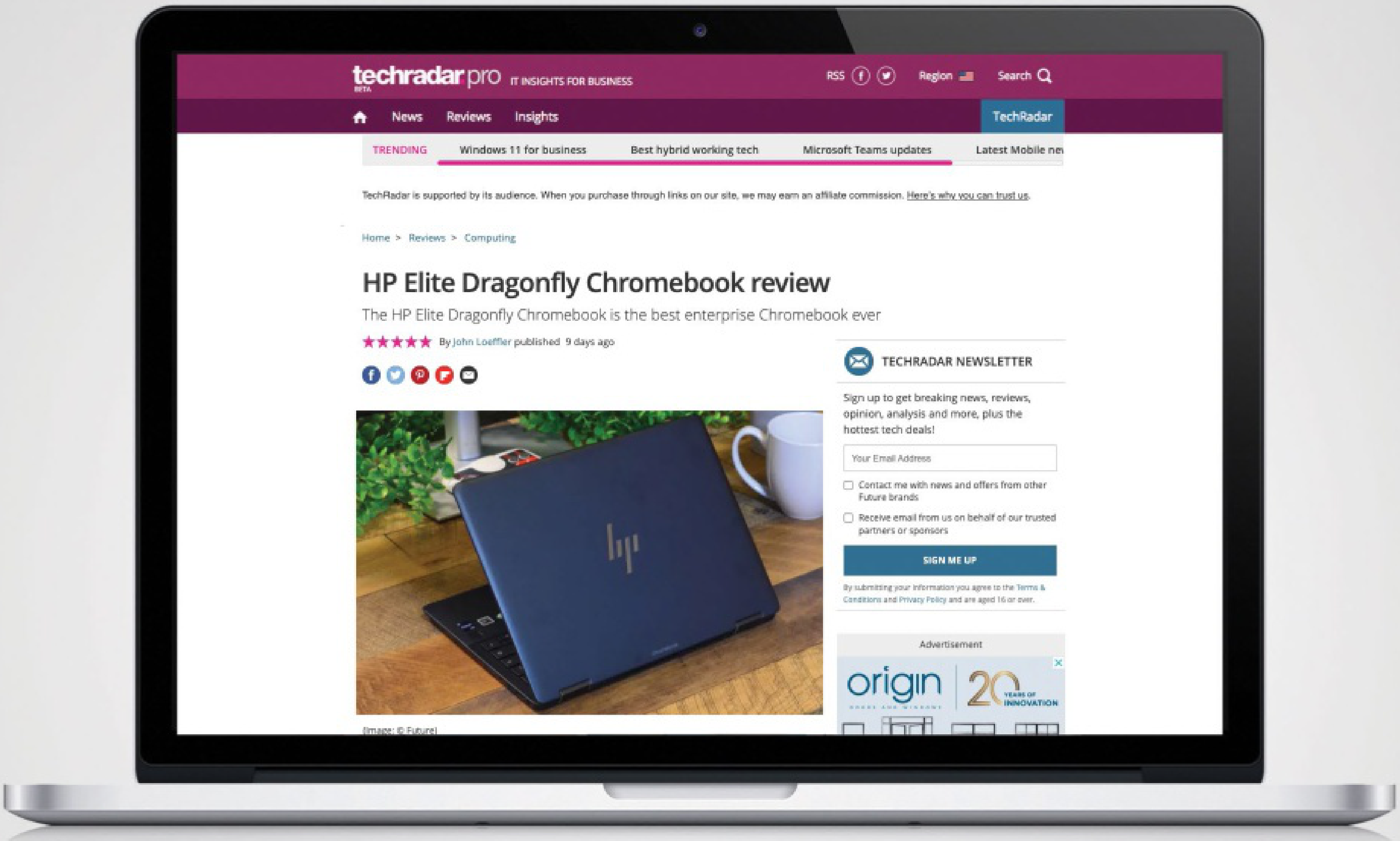

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★★★★★ By John Loeffler published 9 days ago

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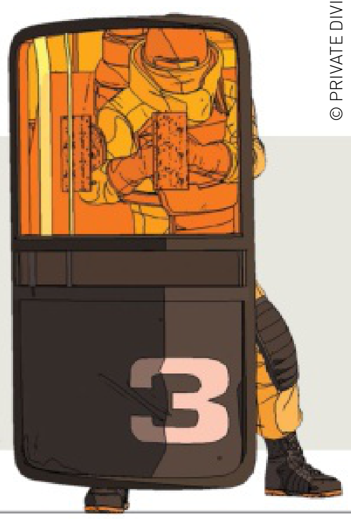

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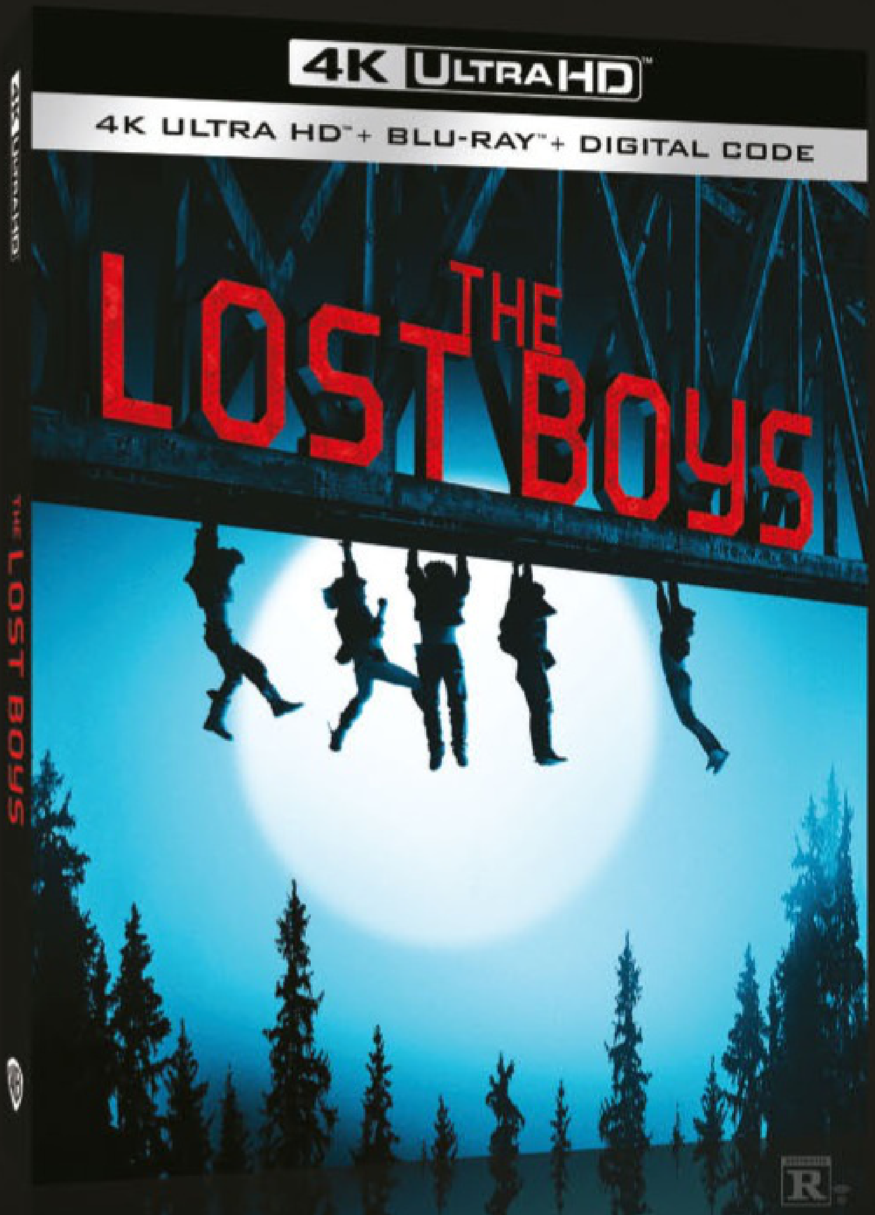
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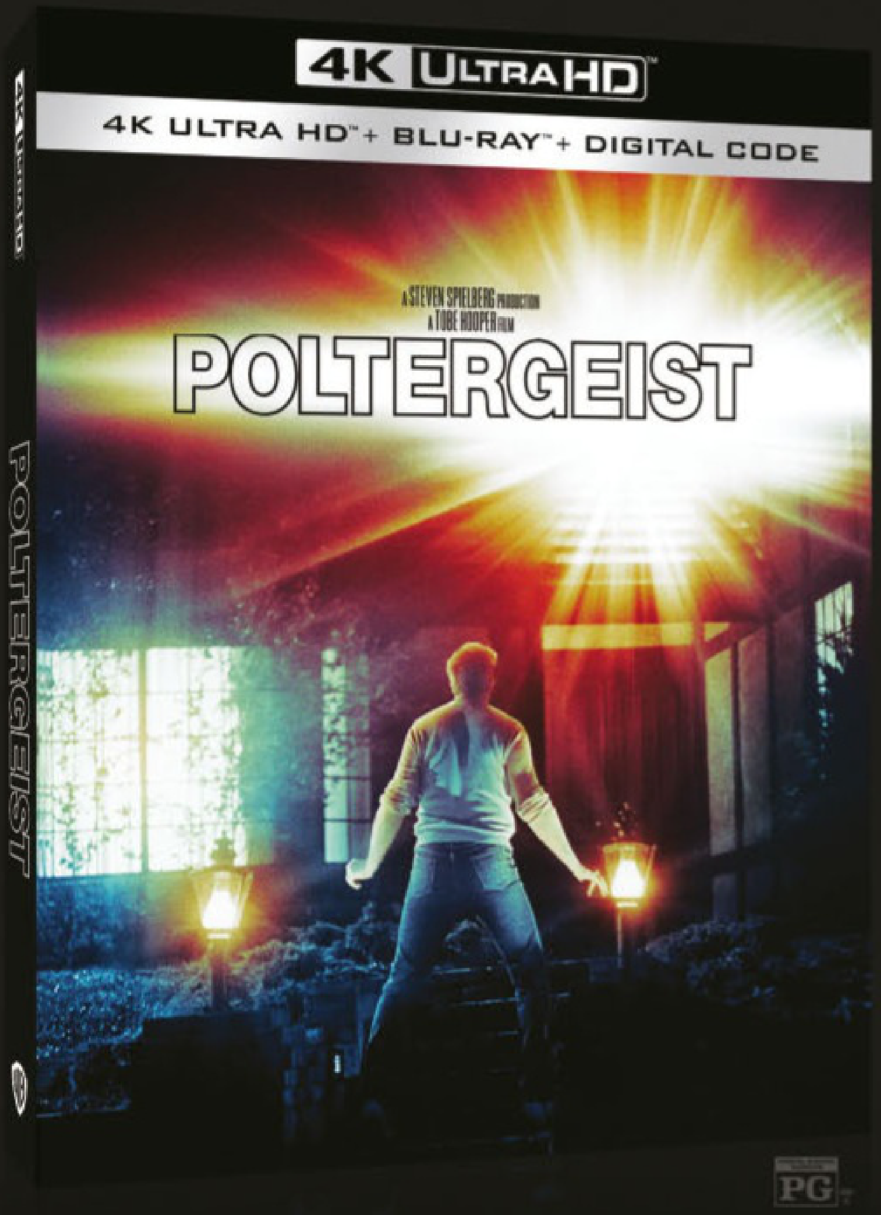
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BARGAIN-BASEMENT GAMING

AS I'M SURE YOU'RE AWARE, AMD has just released its "best gaming CPU" ever in the form of the Ryzen 9 7950X (read all about it in our news section on page 8). It's an exciting debut for the brand new Zen 4 line—the 7950X is around 13 percent faster than its predecessor the Ryzen 9 5950X and, at $699, it's also $100 cheaper. It's a bold statement of intent from AMD that once again lays down the gauntlet to Intel. Luckily, no matter who wins this next generation, the real winner will be us consumers.

You may ask, then, why we've opted for a budget gaming build for this month's cover feature. Don't worry, we will be reviewing, comparing, and building the heck out of all of AMD's (and Intel's) new high-performance chips in the coming months—this is still *Maximum PC* after all. But the arrival of new CPUs also means bargains on current-gen hardware, so we've been able to build a sub-$1000 gaming PC for the first time since May 2019. With the cost of living rising, that's a godsend, as you don't need to splash out to experience brilliant 1080p gaming. Right now, that's the message I feel we should be shouting from the rooftops.

Our master builder Sam has put together an Intel/Nvidia gaming PC that will chew through games at 1080p, has components that are readily available, and costs just $990—unthinkable just a few months ago. He has all the info you need on how to keep this machine up-to-date with minimal effort, plus some great value peripherals that boast a luxury feel without a premium price tag.

On a similar theme, we look at how to turn an old monitor into a digital dashboard, so you and your family can see at a glance all the info you need throughout the day. Sure, devices such as the Amazon Echo Show 15 already do this, but they cost around $250 and aren't as big as that discarded monitor under your desk. It's an ideal weekend project and begins on page 70.

This month, I went to Germany for the return of Gamescom, the world's biggest consumer video games show which has been on hiatus for visitors for the last couple of years. There were great games there, including *Lies of P* and *Metal: Hellsinger*, as well as hardware, such as Corsair's bendable OLED screen and Samsung's huge 55-inch Odyssey Ark display. I've covered all the best stuff you need to know about in my feature on page 50.

Our in-depth feature this month is a look at Taiwanese chip manufacturer TSMC and how it's become the dominant force in the semiconductor foundry scene over the last few years. With Intel set to open up more of its own manufacturing facilities, we ask whether it can possibly compete with TSMC and if having one powerful player is bad for the chip market overall.

Elsewhere in this issue, we finally get to review one of Intel's long-awaited Arc graphics cards. We start with the entry-level A380—has it got what it takes to kick the AMD 6400 and Nvidia 1630 into touch? Find out on page 74. And fear not, performance enthusiasts, we should have some high-powered 4000-series cards for you from Nvidia before the end of the year!

Enjoy the issue!

Guy Cocker

Guy is Maximum PC's Editor-in-Chief. He built his first gaming PC in 1997 to play Tomb Raider on 3dfx, and has been obsessed with all things PC ever since.

↘ submit your questions to: editor@maximumpc.com

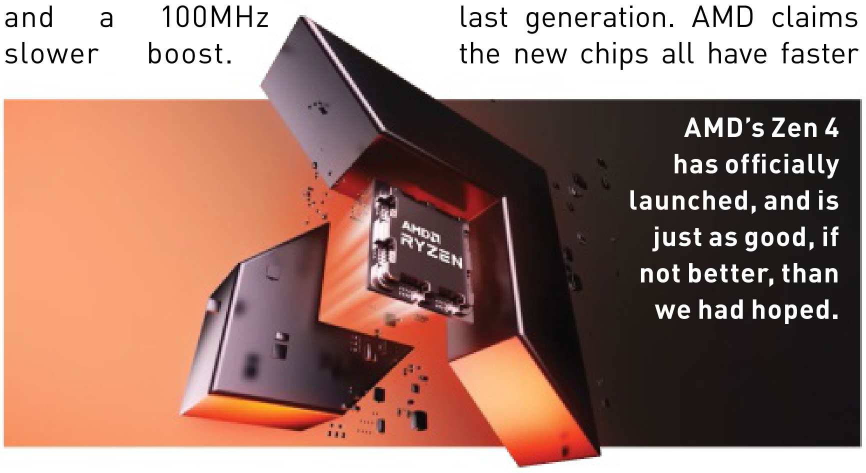
THE NEWS

Zen 4: all that we'd hoped for

AMD's latest is fast and efficient—and the fight is on!

AND SO it begins. AMD's Zen 4 has landed and Intel's 13th generation Raptor Lake chips aren't far behind. The fight for CPU supremacy is on. First, those new AMD chips. The Zen 4 range starts with four new models. At the top is the Ryzen 9 7950X, with 16 cores and 80MB of L2 and L3 cache. The base clock is 4.5GHz, with a boost to 5.7GHz, and costs $699. Next is the Ryzen 7900X ($549) with 12 cores, a 200MHz faster base clock, and a 100MHz slower boost. Both chips have a TDP of 170W, and a 'maximum' power consumption of 230W, so toasty rather than hot. Then there's a Ryzen 7 7700X with eight cores and a clock of 4.5GHz at $399. Lastly, the Ryzen 5 7600X has six cores, a clock of 4.7GHz, and a price of $299. So we get 16, 12, 8, and 6-core versions, all with 5.3GHz or better boost clocks. All chips use DDR5-5200 RAM and support PCIe 5.0. Prices are reasonable too, with the Ryzen 9 7950X $100 less than the Ryzen 5700X at launch. Lower down, chips are priced in line with their predecessors.

Improvements include a claimed instructions per cycle bump of 13 percent thanks to the new core architecture—that's better than the eight to ten percent AMD had originally expected. Clock speeds are a hefty improvement on Zen 3, with that 5.7GHz boost speed a full 800MHz faster than the last generation. AMD claims the new chips all have faster single-thread performance than their competition, in this case, an Intel Core i9-12900K.


AMD's Zen 4 has officially launched, and is just as good, if not better, than we had hoped.

Perhaps as impressive as the raw power is the power consumption, as Zen 4 manages the same performance as Zen 3 while using 62 percent less power—concerns about run-away power consumption have proved groundless. If AMD's figures prove accurate, Zen 4 is an impressively efficient chip. This is attributed to lessons learned developing mobile chips and the die shrink, including a new 6nm I/O chip. There are new motherboard chipsets too—the X670, for maximum performance, with lots of I/O options, including PCIe 5.0 storage. These will be followed by the less adventurous B650 chipset. The AM5 platform will include AMD EXPO (EXtended PrOfiles) technology, which enables one-click DDR5 overclocking.

AMD is keen to tell everyone how fast the Zen 4 is and has bar charts to prove it. The figures aren't verified, but AMD claims the chips are 15 percent faster than the Zen 3 in 1080p gaming, and 40 percent better at content creation. Pitted against a Core i9-12900K for gaming, and depending on the title, they are as good at worst, and 24 percent better at best. At content creation, they are up to 62 percent faster. The 7000-series Ryzen is more of an upgrade than many expected, and this is before we've seen any 3D V-Cache versions, which should be proper little monsters.

Whatever AMD's slides may say, the Core i9-12900K isn't the Zen 4's real rival. That would be the forthcoming Raptor Lake series. The top chip here is the Core i9-13900K with eight performance cores, an impressive 16 efficiency cores, a base clock of 4.5GHz, and a top boost of 5.8GHz. Power consumption is quoted as a TDP of 125W and a maximum of 253W. Next is the i7-13700X, which loses eight efficiency cores, has a base clock of 3.4GHz, and a maximum boost of 5.4GHz.

The full range is too extensive to fit here, but as with AMD, we get DDR5 memory, PCIe 5.0 support, and a two-digit IPC increase. Intel's hybrid design, mixing power and efficiency cores, has proven itself with Alder Lake, and there's every indication that Raptor Lake won't disappoint. It looks as if it will be a hotter chip, temperature-wise. There are also rumors of an 'unlimited power' mode on some 700-series motherboards to allow you to crank up the wattage. Given sufficient cooling, that should be interesting.

As soon as people get hold of these new processors, they will benchmark them. Early tests can be unreliable, so we'll wait until we've got our hands on the hardware before we're convinced. However, word is that this is a close fight. If the performance of the two processor families proves too similar, we may have to fall back on that most fundamental of arbiters: dollars. **–CL**

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DUCKDUCKGO RELEASES PRIVATE EMAIL

YOUR EMAILS AREN'T SAFE from prying eyes. Google collects data from Gmail, which is crucial to its core business. It stopped directly scanning emails in 2017, but still collects data on your activities. DuckDuckGo is an advocate of privacy and its search engine won't track you. It has extended this approach to emails with its Email Protection service. It's not a traditional account, but a forwarding service. You get a @duck address, and your emails are funneled through this from your original address, with all tracking codes being stripped out of messages. DuckDuckGo claims that, during beta testing, 85 percent of messages contained hidden trackers. The system can create a unique private address, making tracking more difficult. Until data collection is responsibly handled, such services are the only way to ensure you aren't being watched. **–CL**

WIN11 22H2 UPDATE IMMINENT

First significant Win11 update brings new features

IF THE WHISPERS PROVED TO BE CORRECT, then Windows 11 Update 22H2 should now be available. The first significant update of Win11 will introduce a few new features and a refreshed look. Windows Store gets a redesign and Widgets are back. Microsoft's 'fluent design' aesthetic will be more in evidence, while the Taskbar regains drag-and-drop support plus an overflow menu. The Start menu now has three settings to modify the Recommended section. It also gains folders, so you can collect apps together into groups by dragging one on top of another. File Explorer also gets a redesign, with tabs (at last), a new navigation pane, and previews of files within folders. Many aspects of Windows have been tweaked, much of it triggered by feedback from users and beta testers. You'll also be able to uninstall updates from the Settings app, just in case one of them causes problems—there's always something that breaks somewhere. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

✓ **AI BEATS HUMANS**
A picture submitted into the digital category of a fine art competition has won, despite being made by an AI algorithm.

✓ **EVERY CONSOLE EVER**
A collector put his collection of around 2,400 consoles on eBay for an opening price of $1m.

✓ **FIRST EXOPLANET CO2**
The James Webb space telescope detected a trace of CO2 on a planet 700 light-years outside the solar system.

TRAGEDIES

✗ **TIKTOK TRACKING**
A researcher discovered that TikTok uses Javascript that can track keystrokes, potentially including passwords.

✗ **NFT MARKETS CRASH**
NFT marketplaces have been in free fall, with transactions dropping by up to 99 percent.

✗ **DODGY PORTABLE SSDS**
Cheap drives with exaggerated capacities for sale online retain the directory structure, so you won't know until you read a file.

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INTEL HINTS AT LOWER PRICES

Alchemist has been disappointing, but can Intel turn it around?

AT AN INVESTOR meeting in February, Intel promised to ship four million Arc graphics cards this year. We're still waiting. The only Intel card currently available is the low-end A380 ($139). It proved a disappointment (see page 74 for the review). The mid-range A750 and A770 are due to launch by the time you read this. The first samples are being inspected, and the A770 is expected to perform somewhere between a GeForce RTX 3060 and 3060Ti, and a bit faster than the Radeon RT 6600XT.

What went wrong with Intel's much-anticipated entry into the graphics card market? Intel's Tom Petersen (a graphics guru poached from Nvidia) cited 'readiness' as the reason for the delays. There were issues with supply lines, but the big problem is software-related. The lack of decent DX11 support disappointed reviewers of the A380. Intel says it's 'looking ahead' by concentrating on DX12, a justification that pleased nobody.

Worse followed, as it became clear that the driver was nowhere near ready, with some features simply broken. It's not a disaster, but testing revealed the A380 had issues with about one in five older games. Arc is optimized for systems with Resizable BAR too, a method to accelerate large copy operations. Without this, it loses a big chunk of performance, so much that Petersen advised those whose rigs lack support to avoid A-series Arc cards.

Intel is aware of the negative press generated by the problems and is running damage-limitation where it can. AMD and Nvidia launch new generations of cards by starting with the top-tier models, and after thorough testing. Intel's tactics inverted that and have been a mess so far. It's a pity because there is decent silicon with real potential. Intel has hinted it won't price the 16GB version of the A770 "as aggressively as we were going to". That may gain Intel friends, especially if the software problems are ironed out. **–CL**

intel ARC
intel ARC

NVIDIA DOUBLES POWER

High expectations for Nvidia's next-gen GPUs, but the wait goes on

BY NOW, WE WERE hoping to have official news of Nvidia's next-generation graphics cards, but it seems we'll have to wait just a little bit longer. The 4000-series will be based around the new Ada Lovelace GPU, which will reportedly bring a massive speed jump. Some reports talk of a doubling in performance, which seems, frankly, wishful. Figures of between 66 and 80 percent sound more achievable, while still being remarkable enough.

The freshest rumor is that we'll only see one card this year, an RTX 4090, which is in production now, according to a leaked production log from a third-party card builder. Apparently, Nvidia has also restarted production of the 12GB RTX 3080 so it can use some of its stock of GA102 GPUs. Much has been made of the sheer size and prestigious power consumption of the first cards: the top-tier GeForce RTX 4090, and 4090Ti.

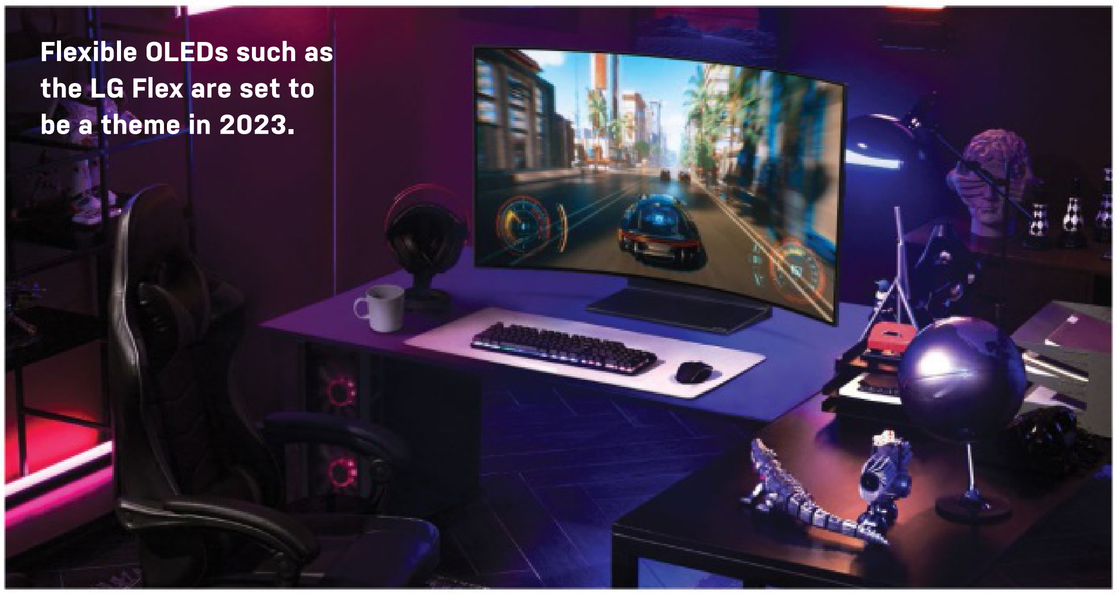
Images of an engineering sample show a beast sporting triple fans. These cards are going to be big and run hot. In the face of the forthcoming cards, the prices for the previous generation of cards have begun to slide, with the RTX 3090 now selling for under $1,000 (at launch, the price was $1,500), and the RTX 3080s going for under $750.

Meanwhile, AMD has its RDNA3 architecture in the wings, scheduled to follow Nvidia in a month or two. It's a more complex design than Lovelace and promises a similar major performance bump. The tussle between Nvidia and AMD's new generations of graphics cards looks likely to be every bit as tight as Intel and AMD's in the CPU space. **–CL**

Flexible curves

A CURVED MONITOR on a larger screen is a great idea. Your eye is at a similar distance from all parts of the screen, minimizing distortion and reducing eye strain. They also expand your peripheral vision, offering a more immersive world. LG, pioneers of curved screens, has developed a new use for its flexible OLED screen. The first television to use them is the LG Flex TV LX3, a 4K, 16:9, 42-inch screen with motorized controls that adjust the curvature from flat to an impressive 900R (ie. a radius of 900mm). You can set it to 20 curvature levels, and it uses the Alpha 9 Gen 5 image processor, LG's high-end model. It has a resolution of 3,840x2,160 and a maximum refresh rate of 120Hz. There are a host of other features you would expect on a high-end television, including HDR. It's perfect for both gaming and general viewing.

Corsair also has a new adjustable screen, this time aimed at the gamer. The Xeneon Flex 45WQHD240 uses a similar LG OLED panel, but with specifications more suited to gaming. The 45-inch screen has an aspect ratio of 21:9 and a resolution of 3,440x1,440 running at a speedy 240Hz, with a gray-to-gray response time of 0.03ms, and a 0.01ms pixel on/off time. There are no motorized controls, instead, you use a pair of handles to adjust the screen manually, which is a little alarming to watch. It's adjustable from flat to an immersive 800R. Peak brightness is 1000nits, with an impressive 1,350,000:1 contrast rating. The vertical resolution is a little low for such a high-end screen, but otherwise, the specifications are tasty. Both flexible wonders will be available this fall—no news on prices yet, but expect your wallet to wince. **–CL**


Flexible OLEDs such as the LG Flex are set to be a theme in 2023.

USB 4 goes twice as fast

The people behind the USB standard have announced the 'pending' release of a new one: USB4 Version 2.0. This will double speeds to 80Gb/s over USB Type-C cables, making USB faster than Thunderbolt 4. Version 2.0 will also update power delivery specifications, and has protocol updates for DisplayPort and PCI Express. It has been achieved using a new 'physical layer architecture' using existing 40Gb/s Type-C cables, or new active Type-C cables. Apparently developed for people running multiple devices on a single port, we will find out more about USB4 V2.0 at the USB Developer's Conference in November. **–CL**

Amazon acquires iRobot

Amazon's latest acquisition is iRobot, makers of the Roomba vacuums, for a cool $1.7 billion. Roomba has the biggest slice of the worldwide robot vacuum market at about 46 percent, more than twice its nearest competitor. Of course, that robot also collects data, which Amazon will now have.

The size of your home may not sound important, but to a data-driven company like Amazon, it is. The location, size, layout, and even flooring materials of your home build into a useful—and saleable—set of marketing data. Allowing internet-connected devices into your home means you'll build a file of useful marketing data that doesn't belong to you. **–CL**

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Jarred Walton

TECH TALK

AMD Ryzen 7000 Lineup Revealed

WE TOOK A DEEP DIVE into AMD's Zen 4 architecture a couple of issues back, but there were still a few unknowns regarding the upcoming processors. AMD has finally pulled the wraps back and filled in the blanks, with the first Ryzen 7000 series parts launching on September 27—which means that by the time you're reading this, they should already be on sale.

Generational pricing sees some dips and bumps, depending on the model. The top Ryzen 9 7950X will see a $100 drop to $699, while the Ryzen 7 7700X will cost $399, $100 more than the outgoing 5700X. The Ryzen 9 7900X sticks with the $549 price point and the Ryzen 5 7600X lands at the same $299 price as the outgoing models. Of course, street pricing on the 5000 series has changed significantly over time, with the various processors selling anywhere from $100 to $250 below MSRP right now.

Performance should be a major improvement over Zen 3, thanks to architectural enhancements that AMD claims deliver a 13 percent higher IPC (instructions per cycle). Tack on boost clocks that are 15-17 percent higher and we're looking at a potential 30 percent gen-on-gen increase. That won't be universal, but power limits are also higher and should allow the Ryzen 7000 chips to reach their maximum throughput more consistently.

Looking at the previous Ryzen families, that 800MHz increase in clock speed will be huge. Zen+ CPUs only clocked 200MHz higher than the original Zen, Zen 2 provided up to a 400MHz increase, and Zen 3 was back to a 200MHz improvement. It's surprising to see AMD's first generation of 5nm CPUs clocking well into the 5GHz range, as we'd heard rumors that TSMC's N5 might not scale clock speeds much. Clearly, AMD figured out a way around any potential limitations.

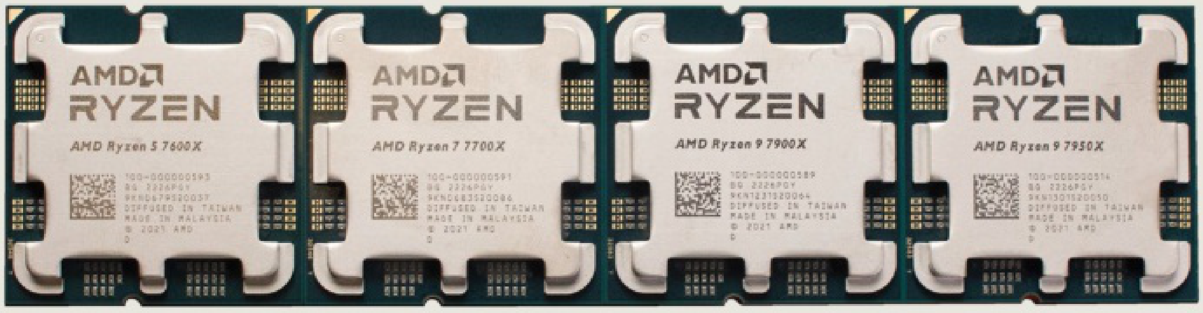
But the real competition will be Intel's Raptor Lake processors, which may be on sale as you read this. We haven't received official prices or final clock speeds, but we know Intel is increasing E-cores across the lineup, putting the Ryzen 7000 in an interesting position.

The Core i9-13900K has eight performance cores with Hyper-Threading and will double the number of efficiency cores relative to the current 12900K, 16 E-cores total. That gives it 24 physical cores and 32 threads. Maximum boost clocks on the P-cores will reportedly reach 5.8GHz as well. That means for the first time since the Ryzen family of CPUs arrived five years ago, Intel will lead in physical core counts over AMD—and as noted here previously, HEDT won't be around to boost core counts in the consumer sector.

More problematic for AMD will be the lower-tier offerings, with Core i5-13400 set to provide six P-cores and four E-cores (16 threads total), while the i5-13600K will feature a 6+8 arrangement. Both chips could provide stiff competition for AMD's Ryzen 5 7600X, which only has six cores and 12 threads. Intel's 13th Gen processors will again support both DDR4 and DDR5, meaning Intel will be better positioned for the midrange and budget markets.

Intel will be on its second round of LGA1700 chips and AMD will have its first new platform since the AM4 launch in 2017. AMD also makes the switch to DDR5, which carries up to a 100 percent increase in cost for the same capacity and relative speed as DDR4.

Things are shaping up for a showdown between AMD and Intel CPUs this fall, and we're not yet sure which chips will rise to the top. If you haven't put together a new PC in the past year or two, both sides are hoping to tempt you into an upgrade. It's going to be an exciting battle, just as we like it.



AMD's Ryzen 7000 series should see up to an 800MHz increase in boost clocks.

© AMD

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

THE LIST

THE TOP FIVE PC GAME CONTROLLERS

MOUSE AND KEYBOARD is the godlike choice when it comes to playing games on PC, but even we have to concede, there are times when a good old game controller does it best. Thankfully, there are some excellent choices for PC gamers who want to play just like their console brethren. This can only be a good thing, especially given the number of PlayStation and Xbox titles being released in their definitive form on our platform of choice.

5

POWERA SPECTRA INFINITY ENHANCED

PowerA's officially licensed Xbox controller is wired and covered with lighting, but its main draw is that it's a great controller at a brilliant price. It's just like Microsoft's own Xbox controller, except it also has two programmable buttons on the rear. **$45, www.powera.com**

4

SONY DUALSENSE WIRELESS CONTROLLER

The PlayStation 5's native controller is the most advanced, technically speaking, thanks to its brilliant haptic motors and adaptive triggers. Sadly, the majority of PC games don't support these advanced features, but the tide is beginning to turn—Marvel's *Spider-Man Remastered* integrates with Sony's DualSense and we expect more PlayStation ports to follow. **$69, www.playstation.com**

3

RAZER WOLVERINE ULTIMATE

The Wolverine Ultimate is a great choice if you game across both Xbox and PC, but there is a catch—it can't connect to the PC wirelessly. The pad's USP is its clicky face buttons, which feel like mouse buttons for a satisfyingly tactile response. This being Razer, there's also Chroma RGB support, although it's done through a separate mobile app, not a native PC one. **$160, www.razer.com**

2

SCUF INSTINCT PRO

This premium controller is the main competitor to Microsoft's official pad (below) but offers a huge variety of cosmetic options. There are new faceplates and thumbsticks to choose from, the latter of which vary in terms of length and topper. You can also remove the rumble motors if you're an eSports player who doesn't need such distractions. **$200, www.scuf.com**

1

XBOX ELITE WIRELESS CONTROLLER SERIES 2

The only downside to using Microsoft's reassuringly expensive game controller is that it makes all standard controllers feel cheap and nasty in comparison. It's luxurious to hold, has a host of customization options, and multiple controllers can connect to one USB wireless dongle (not included). The controller also comes with a charging case and can be used wired or wirelessly. **$180, www.xbox.com**

© MICROSOFT, SCUF, RAZER, SONY, POWERA

Jeremy Laird

TRADE CHAT

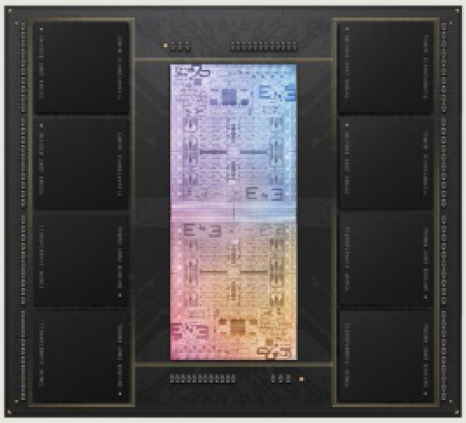
Plenty Moore where that came from…

AS I PERUSED THE ACHIEVEMENTS of TSMC for this month's feature on the Taiwanese chip foundry's rise to world dominance, something occurred to me. What happened to the end of Moore's Law? Not long ago, it was game over for shrinking transistors and ever more powerful and cheaper computer chips. But now, TSMC is about to start banging out 3nm wafers.

Intel also insists it will regain process node leadership before the end of the decade, which implies at least two or three process shrinks in the next five years. Turning sand into high-performance silicon chips containing billions of individual components is one of the greatest technical achievements in human history. But for a while in the 2010s, it looked like progress was going the same way as supersonic travel. We'd hit a wall. But TSMC upped its game and the rest of the industry is being dragged along with it.

In terms of truly mass-produced computer chips for commercial consumption, only TSMC, Intel, and Samsung factor when it comes to operating right at the cutting edge. While only these companies can produce the most advanced chips in retail volumes, several others are critical in enabling that to happen. The best known is ASML, the Dutch outfit that makes the EUV or extreme ultra-violet lithography machines used by the big three to etch the tiny features into the silicon wafers.

Just as important is IMEC, a research outfit that helps the big boys advance their process tech. Earlier this year, IMEC unveiled a roadmap reaching right out to 2036. IMEC isn't explicit about it, but it's clear its nomenclature aligns with TSMC's commercial nodes, with N7 or 7nm placed in 2018 and N5 or 5nm in 2020. Predictably, IMEC has N3 inked in for later this year.



Apple's epic 114 billion transistor M1 Ultra chip proves that Moore's Law is still alive and kicking.

© APPLE CORP

But it's the rest of IMEC's roadmap that's really exciting. IMEC reckons 2024 will see a new 2nm node, with a so-called A14 node in 2026. A14 refers to 14 angstroms, equivalent to 1.4nm. The A10 node follows in 2028 with new nodes slated every two years up to 2036 and A2, the same as 0.2nm.

> Don't ask me how, but my money is on Moore's Law advances continuing beyond 2036.

Of course, none of these measurements, in nanometers or angstroms, directly correlate with the actual size of chip features. But the point is that IMEC can see all the way to 2036 and thinks it can deliver nodes with significant feature size shrinkage every two years over that period, keeping Moore's Law on track. Lest you have forgotten, Moore's Law is the observation by Intel co-founder Gordon Moore that integrated circuit complexity doubles every two years. Moore made that observation in the mid-70s and it has proved remarkably prescient ever since. For example, Apple's latest M1 Ultra APU packs 114 billion transistors and falls slightly above the logarithmic line predicted by Moore's Law.

IMEC's roadmap includes several new technologies that will help achieve that scaling to 2036, many of which have already been developed. One example is the CFET or the complementary field-effect transistor. It's the next evolution of the latest GAAFET (gate all-around field-effect transistors) that TSMC is set to use for its 3nm node and Intel is planning for its own A18 node.

In 2036, an even more exotic transistor structure is planned, known as atomic level sheets or 2D transistors. Created using tungsten disulfide to form self-assembly 2D structures just one atom thick, you'd think the industry will have hit the wall. But then rumors of Moore's Law demise have been exaggerated in the past.

Don't ask me how they will do it, but my money is on the advances continuing beyond 2036. By then, today's 5nm chips with their billions of transistors will look like a 90s pocket calculator does today.

Six raw 4K panels for breakfast, laced with extract of x86… Jeremy Laird eats and breathes PC technology.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Driver Updater
> Plex security breach
> Adobe CS3 options

Driver Updater query

I have a question about driver updaters. AVG charged me for such a program recently. I wondered why I was being charged for this since I had a two-year subscription to its Ultimate package. Turns out AVG has a new software app that updates not only its software drivers but everyone else's drivers too.

Oddly, a company like Microsoft charges third-party companies that use its operating system lots of money to 'authenticate' drivers, but suddenly, AVG has 20,000 other manufacturer drivers to update. It's strange that AVG has moved into this area.

Could you possibly shed light on what is going on with driver updaters and why software manufacturers aren't updating their own drivers? Maybe they are? What is AVG's game here? And why do we need such an app? **—Steven Sherk**

THE DOCTOR RESPONDS: Driver updates are like software updaters in that they're designed for convenience by allowing you to keep all your drivers up to date with a single program. At least that's the theory.

Western Digital
WD RED
SA500
1TB NAS
SATA SSD
Solid State Drive

There's usually space for an SSD in a NAS enclosure.

This means that AVG—or indeed any other driver updater—isn't involved in developing driver updates; instead, it's merely acting as a convenient conduit to them. Hardware manufacturers continue to create their own drivers, then either sign them themselves or submit them to Microsoft for WHQL certification (Microsoft hasn't charged a fee for these tests since 2014).

If a driver is WHQL-certified, it will be added to Microsoft's driver database and can be installed and updated through Windows Update. After installing a fresh copy of Windows for the first time, all installed drivers are WHQL-certified.

The downside of relying on WHQL drivers is that they're rarely the latest available version and prioritize stability over performance. You are encouraged to visit the manufacturer's own website to see if more up-to-date (but not WHQL-certified) drivers are available. Install these and you may improve performance and gain new features, but you're relying on the driver manufacturer to provide updates.

If you're lucky, some hardware manufacturers will supply automatic update checkers as part of their software installations, NVIDIA's GeForce drivers being a case in point. Most hard drive manufacturers offer additional tools that include driver and firmware checkers. That's all well and good, but this piecemeal approach leaves big gaps in your driver update arsenal.

One option might be to bookmark the various support pages covering all the components in your machine, then set yourself a regular day (say once a month) to check each website to see if driver updates are available.

If that's too much hassle, you're struggling to identify certain bits of hardware, or are unable to find drivers, a driver update tool may help. If you don't want to pay for the privilege, you'll find plenty of free options out there—check out our tutorial on page 68 for a guide to using one such tool.

NAS build query

I love the 'Build your own NAS' article in the September 2022 issue of *Maximum PC*. I was lucky enough to source an ASRock J5040-ITX motherboard and the InWin IW-MS04 case as mentioned in a previous issue (July 2020) and was wondering if you could provide some tips on incorporating them into the project. It's been a long time since my last build (I'm 72 years old) and I would really appreciate some help,

↘ submit your questions to: doctor@maximumpc.com especially with the HDD for the OS as I'm not quite sure where to place it. Thank you very much for any help you can provide! I'm looking forward to running my own NAS. **—Frank D Gunsetor**

THE DOCTOR RESPONDS: Luckily, the Doc's own NAS is built around the same components Frank used for his NAS, so he was able to provide the specific advice needed. Let's start with the best placement for the OS drive, which we'll assume is a 2.5-inch SSD. There's a handy space on the side of the chassis where you can slide in your SSD and secure it to the case (see photo). The good news is that there are enough SATA power connectors on the IW-MS04's built-in PSU to cover the boot drive as well as the four additional drive bays.

Where you may come unstuck is in the fact the J5040-ITX mobo only has four SATA connectors, a problem resolved by adding a two-port PCI-E SATA card as outlined in the 'Build your own NAS' feature. It doesn't matter which SATA ports you use for the four 3.5-inch drives, but make sure your SSD boot drive is connected to one of the Intel SATA ports (SATA3_1 or SATA3_2) for maximum performance.

Frank was also interested in using the board's M.2 socket to add Wi-Fi capabilities to his system. The Doc prefers wired connections and would reach for a USB Wi-Fi adapter if required, but you can fit the Intel Wi-Fi 6 AX200 (Gig+) M.2 module to this slot to add Wi-Fi 6 and Bluetooth 5.1. Linux drivers exist for kernel 5.1 or later, which means it should work seamlessly with Ubuntu 22.04 LTS or later (see www.intel.com/content/www/us/en/support/articles/000005511/wireless.html for details on installing it manually). The AX200 can be picked up for around $32 on amazon.com.

Plex password breach

I've just received an email from Plex informing me about a possible security breach and the need to reset my password. What does this entail and is it time to switch to another media server? **—Joff Hopkins**

THE DOCTOR RESPONDS: There's no need to move your media to another server, Joff—although if you're unhappy with Plex you might want to check out Jellyfin (https://jellyfin.org/) as a free and open-source alternative. The good news is you can install and run it alongside Plex using the same media libraries, so you can test it without committing to the switch.

But going back to the point: there's no need to move to another media server, because Plex has been open and transparent about the password breach, and moved swiftly to ensure everyone has changed their passwords. So, with that in mind, let's start by changing your Plex password.

Log into your account settings through your web browser, then click your account avatar in the top right-hand corner and choose 'Account Settings'. Scroll down to the Security section and click Edit next to Password. Check 'Sign out connected devices after password change' before choosing a new, strong password (the Doc recommends a 14-character password, randomly generated by your password manager with a mix of numbers, letters, and symbols. Once done, you'll be logged out, so log back into your account and return to the Security section to enable 2FA for an additional layer of protection.

Note that choosing 'sign out connected devices' will also unlink your media server from your account, which means you'll need to 'reclaim' it. Plex offers detailed instructions on doing this at https://support.plex.tv/articles/account-requires-password-reset/ but assuming you're on the same network as your Plex server, the simplest thing to do is open a new browser tab and go directly to the server's local IP address—for example, http://192.168.35.1:32400/web/—finish the setup wizard and you'll be warned the server is unclaimed and not secure. Click the 'Claim it now' button and follow the prompts to relink the server to your main Plex account.

Finally, you'll need to sign back in on all your playback devices—it's a pain, but at least Plex supports signing into TV apps using a four-digit code you can obtain by logging into your Plex account on any web browser. And don't worry about any remote users not heeding the call to reset their passwords, Plex has made this a mandatory step, so until they sort out their password they won't be able to access your server.

CS3-friendly upgrade

I have a computer running Adobe CS3—it's a Gigabyte GA78LMT-USB3 with AMD FX 8350 and NVIDIA Quadro K620 powered by Windows 7. It seems that to keep CS3 I must stick with what I have and live with it. I don't know if the mobo is compatible with a new PCI-E 4.0 graphics card, but do I need all the power that the graphics card requires? I have a 450-watt power supply and can't see an affordable update path. Due to the ridiculous power demanded by gaming GPUs is there any upgrade path for low-power users? **—Leslie Nelson**

THE DOC RESPONDS: Ordinarily, the Doc would have pointed you towards running Adobe CS3 in a virtual machine to enable you to keep it running without hobbling your need to upgrade your system. Ordinarily. The problem is that Adobe's CS3 activation servers were discontinued a while back, and after the company made an installer with offline activation available to download for a short period, that has now been removed, meaning CS3 is completely dead.

This highlights another potential issue, what happens if your current install stops working and can't be resurrected? The Doc sympathizes with your reluctance to upgrade—why does Adobe insist we rent software instead of purchasing it outright?—but wonders if now isn't the time for a discussion about what you use CS3 for and whether you can transfer to a more up-to-date package from a rival publisher. Serif's Affinity range (https://affinity.serif.com) offers alternatives to Photoshop, InDesign, and Illustrator that can be bought outright. The total cost of all three products is under $165, so it may be worth exploring to see how other CS users have fared in migrating.

In terms of upgrading your current system to continue running CS3, there's little to be gained from swapping out the graphics card. The mobo only supports the PCI Express 2.0 standard for starters, but the graphics card is of little importance with 2D graphics. Upgrades that will make a difference, if you haven't already applied them, would be to replace a platter-based hard drive with an SSD boot drive and to max out your RAM to 32GB.

Although your mobo only supports SATA-II speeds, there's plenty of bandwidth for an SSD drive to deliver a noticeable uplift in performance, from simple loading of apps to overall responsiveness. If you're determined to keep CS3 running on this system, those are the two upgrades to focus on. ⏻

BUILD A $990 GAMING PC

Gaming on a budget? We show you how to build a machine for under $1,000

OK, so times are tough right now and the price of everything seems to be going up by the day, but that doesn't necessarily mean you have to put those PC building plans on hold just yet. Stick to a budget of around $1,000 for a new PC and it's possible to get a smooth 1080p gaming experience at a reasonable price.

So, where do we start? Let's begin by choosing our sides—are you team Intel or team AMD? In this budget offering, we've gone down the Intel route with a 12th generation i5-12400 CPU. Alongside a Zotac RTX 3050, this should provide a decent gaming experience. Working to a budget brings a few constraints, of course. Not only do we have to choose our components carefully, but they also need to match each another to give you a machine that's not just capable of gaming but is also a reliable workhorse.

Thankfully, we've lined up a range of parts that should make this PC a strong rig to complete an array of tasks from simple admin and watching Netflix to some solid gaming. With this machine, we're hoping to show that for a relatively modest outlay, you can game comfortably and also build a PC with future-proofing in mind. Especially with the 12th generation Intel chip we've chosen, it should last for some time yet.

We'll run down how to go through the basic setup process and what to do to your machine before leaping into a game of *Warzone*—yes, we know how eager you'll be to get straight into using your PC as soon as you've built it. We'll also show you some great starter peripherals so you can get right into the action with your new PC. So what are we waiting for? Let's do this. –SAM LEWIS

INGREDIENTS

PART		STREET PRICE
Case	NZXT H510 Flow ATX Mid Tower Case	$90
Motherboard	ASRock B660M-ITX/ac	$119
CPU	Intel Core i5-12400	$194
CPU Cooler	Intel Laminar RM1 Cooler	$n/a
GPU	Zotac GeForce RTX 3050 Twin Edge 8GB GDDR6	$320
Memory	16GB (2x 8GB) Corsair Vengeance RGB RS DDR4-3200	$70
SSD	1TB ADATA XPG GAMMIX S70 w/ Heatsink PCIe 4.0 NVMe SSD	$109
PSU	Corsair CV450 80+ Bronze PSU	$55
OS	Windows 11 Home 64-bit OEM	$32
TOTAL		$989

PRICES CORRECT AT THE TIME OF PRINTING

BUILD IT PG.22

NZXT
CORSAIR
CV450
ZOTAC GAMING
GEFORCE RTX
ZOTAC
intel
B660M-ITX/ac
ASRock
VENGEANCE
VENGEANCE
XPG

INTEL LAMINAR RM1 COOLER

$N/A

Intel's new 12th gen stock coolers are far better performance-wise and visually than previous versions. They actually look as if they were designed to be seen. Who would have thought it? Although you can't physically purchase one, ours came with the Intel i5-12400 chip and it works across all 12th gen Intel Core CPUs.

It's a simple CPU cooler that fixes onto the motherboard using four push-in clips and should be all we need for our budget gaming system. With plenty of airflow thanks to the case, and generally low thermal temperatures coming from the i5-12400, the RM1 cooler is a suitable solution for our build and a step in the right direction for stock coolers.
www.intel.com

intel
INTEL® CORE™ i5
i5-12400
SRL4V
V134J146

INTEL CORE I5-12400 $194

Our humble Intel Core i5-12400 can easily be overshadowed by the more powerful chips in the Alder Lake range.

It doesn't follow the same hybrid architecture that can be seen in the likes of the i9-12900K as all its cores are performance oriented. However, there is more than meets the eye when it comes down to the processor.

For future-proofing purposes, the i5-12400 has huge overclocking potential, which is ideal for squeezing extra free power out of this build. As well as that, it can be picked up for around the $200 mark. For that, you're getting a 6-core, 12-thread processor with a 4.40GHz max turbo frequency. It also features integrated UHD Graphics 770 so you could run this without a GPU for low-end gaming, if necessary.

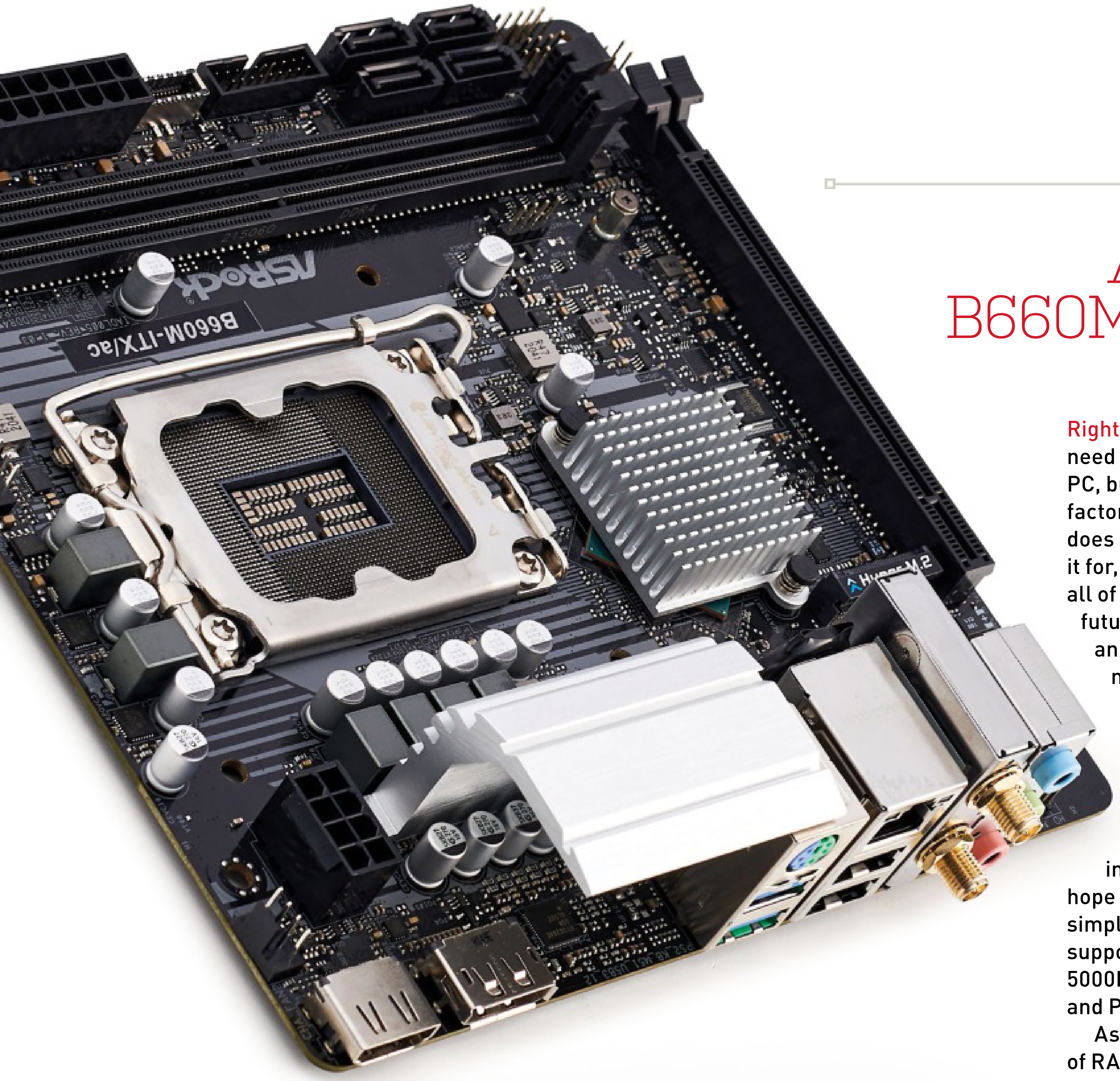
Overall, it's a reliable chip and shouldn't use too much power whilst staying relatively cool. **www.intel.com**

ZOTAC GAMING GEFORCE RTX 3050 TWIN EDGE 8GB $320

To match our CPU, we've the budget offering from the RTX 30 series, the 3050. Just like the processor, this provides more than it may initially appear. When a product sits at the bottom of a list it can be hidden by its more powerful siblings. Yet, this compact card is still a capable GPU that should provide you with all you need for stable 1080p gaming, on paper at least.

Technically, this features NVIDIA's Ampere architecture, 8GB of GDDR6 memory, with 2nd gen ray-tracing cores and 3rd gen tensor cores for some impressive performance. Its two-fan, sleek design means it doesn't take up a lot of case real estate either. Thankfully, we have plenty of room in our case but this would make a good choice for smaller form factor builds too. Fingers crossed we'll see some consistent and strong fps scores when gaming with this 3050.
www.zotac.com

BUILD IT PG.22



ASROCK B660M-ITX/AC

$119

Right, we know that we didn't need an ITX board for this PC, but we like small form factor builds. So it's tiny, does exactly what we need it for, is compatible with all of our components with future-proofing in mind, and is cheap. Okay, there's more to it than that, but we aren't wrong about those points above.

This mobo is great value for money. Sure, it doesn't have as many USB ports in its I/O shield as we'd hope for but that's nothing a simple USB hub can't solve. It supports PCIe 4.0, DDR4 up to 5000MHz, 12th gen Intel CPUs and PCI express 4.0 M.2 SSDs.

As we've only got two sticks of RAM for this build, we aren't too bothered by it not having four DIMM slots. However, if you wanted to upgrade your memory down the line, this could be a problem.

www.asrock.com

VENGEANCE
VENGEANCE

16GB (2x 8GB) CORSAIR VENGEANCE RGB RS DDR4-3200 $70

We know RGB divides opinions, but there is a happy medium where you have a gentle glow of color without the need for a rainbow explosion in your case. That's where this 16GB kit of Corsair Vengeance RAM comes in. Other than this, our system is colorless so it's a welcome addition.

Aesthetics aside, this kit provides enough oomph to work in tandem with the rest of our parts. 16GB isn't a groundbreaking amount of memory, but with its speedy 3,200MHz performance, it is a strong addition to our budget Intel machine. It also helps that this is a two-piece kit for once, as we only have two DIMM slots available.

www.corsair.com

CORSAIR CV450 80+ BRONZE PSU $55

Without an AIO cooler and a hungry GPU/CPU combination, a 450W power supply is more than sufficient for our build.

In fact, Zotac recommends a 450W PSU for the RTX 3050 Twin Edge we have in the build. For just over the $50 mark, this Corsair CV450 is great value and a sensible starting point for your budget system. It runs quietly and fits into any standard case easily thanks to a shorter depth compared to a standard PSU.

One drawback is its non-modular design, which means you can't just get rid of unnecessary PSU cables to keep your system as tidy as possible. Also, if any cables manage to get damaged or you want to introduce some custom PSU cables, you can't. For what we need though, it ticks plenty of the right boxes.

www.corsair.com

CV450
CORSAIR
CORSAIR

BUILD IT PG.22

ADATA XPG GAMMIX S70 1TB M.2 SSD $109

If you only have one choice for a storage solution, then an M.2 SSD is the one you should choose. We also had to factor in that we needed an SSD with a heatsink shield as our motherboard didn't come with one. That's not the end of the world, but it still made our SSD more expensive than it needed to be. We've gone for an SSD that proved capable in some recent SSD tests we completed a few issues ago, the ADATA XPG GAMMIX S70.

This speedy storage solution has read/write speeds of up to 7,400/6,800MB/s and a PCIe Gen4x4 interface. Its heat spreader aims to reduce heat temperatures by up to 30 percent and we like the way it looks too. **www.adata.com**

NZXT H510 FLOW ATX MID TOWER $90

On this budget, we're looking for a sub $100 case and, thankfully, there are plenty of options and brands to choose from. NZXT cases offer form and functionality while also looking more premium than that otherwise budget price tag might suggest.

The H510 Flow is a good example of this containing all of these characteristics. The key is in the name when it comes to the Flow variants, as they offer the best airflow over other cases in the range, meaning we should get better cooling results in our system than in a more closed-off case.

It's big enough for our current ITX motherboard and RTX 3050 and has room to improve the system down the line. We love how the black perforated front panel follows the shade and lines of the tinted tempered glass panel around the case. It's a tasty-looking chassis and, for just $90, you can't go wrong. **www.nzxt.com**

BUILDING THE $990 GAMING PC

Is this machine a perfect starting point for 1080p gaming?

LENGTH OF TIME: **1-2 HOURS**
LEVEL OF DIFFICULTY: **EASY**

1

ALWAYS TEAR US APART

IGNORING THE ADVICE from the famous INXS track, *Never Tear Us Apart*, we've done the opposite and dismantled this case to get to its core chassis. You'll have to take most of your system's panels apart when building at some point, so why not take them off right from the start? This helps you get into all the tight spaces of the build when crafting together your masterpiece.

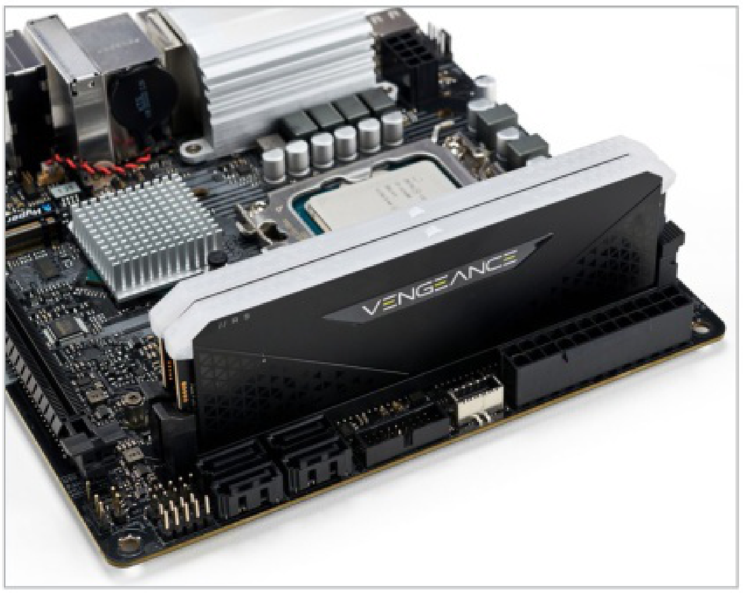
Luckily on NZXT cases, only a few thumb screws will hold you back from stripping the case to bits. One thumb screw holds the glass front panel and the rear panel is secured by two. It's also a good way to plan your cable management early on. Although not entirely necessary, we added another NZXT case fan that we found in our storage cupboard into the front of this case too. This is easily secured using four case screws.

4

A SPLASH OF RGB

ADDING THE RAM is particularly easy on this motherboard. With only two DIMM slots available, we can't exactly mess up the order and we don't have to refer back to the manual either. That means all we need to do is open up the top clips on the DIMM slots, then take one of the sticks of our Corsair RAM, align the notches together, and push it into the board.

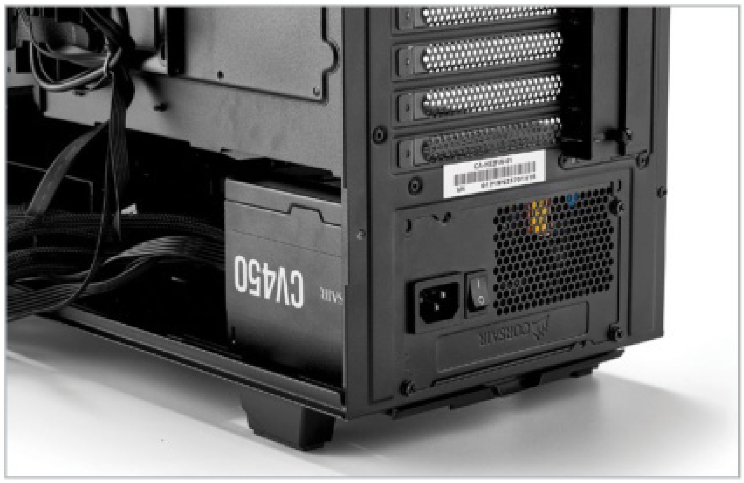
A clicking noise indicates that it's been installed correctly and the clip will fasten, holding the RAM securely in place. Repeat this for the other stick and there you have it, your RAM is installed.



2 THE COUNTERWEIGHT

IN MOST BUILDS, we keep the PSU installation until the end but there's no reason why we can't put it in first here. Especially as it's non-modular, we can hide the cables underneath until we attach them to the motherboard. To make some room, we removed the HDD cage in the bottom of the case as this was about as useful here as a chocolate CPU cooler. This involved a few simple screws from underneath the case and it was out in no time. Whenever we're building, we like as little clutter as possible to help later on with cable management.

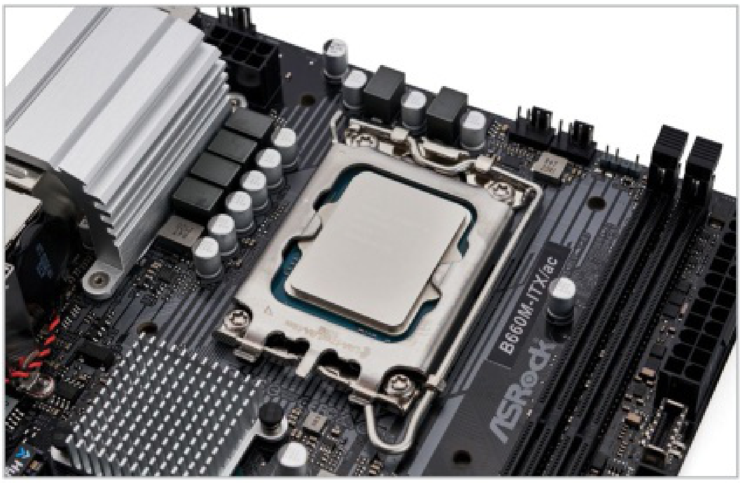
After this, make sure the PSU's fan is facing down and push toward the back of the case. The screw holes will align with the case, then you simply need to tighten it onto the case using a screwdriver.



3 CASE ASIDE

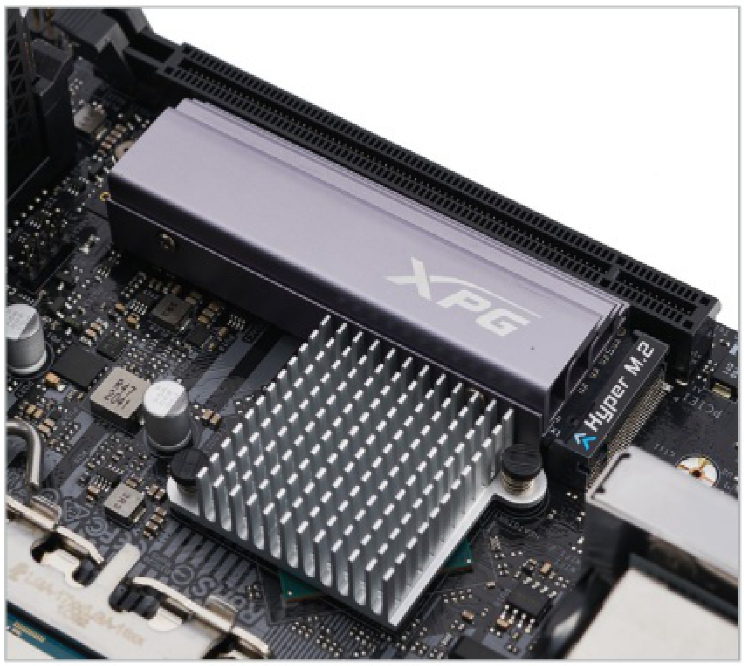
NOW THAT THE PSU is installed into our NZXT H510 Flow, we can turn our attention to getting our machine ticking by installing our CPU on the motherboard. When installing components onto the motherboard, we take the anti-static bag and protection foam from the mobo's box and place them underneath to protect the underside of the motherboard. Once prepared, we can add the CPU. Lift the retention arm of the CPU socket from the place where it tucks underneath.

After this is open, we can take our CPU by grabbing it by the sides and resting it down into the socket. Make sure you align both the triangles together from the CPU and motherboard. Then reverse the process by closing the socket by pulling the retention arm back down.



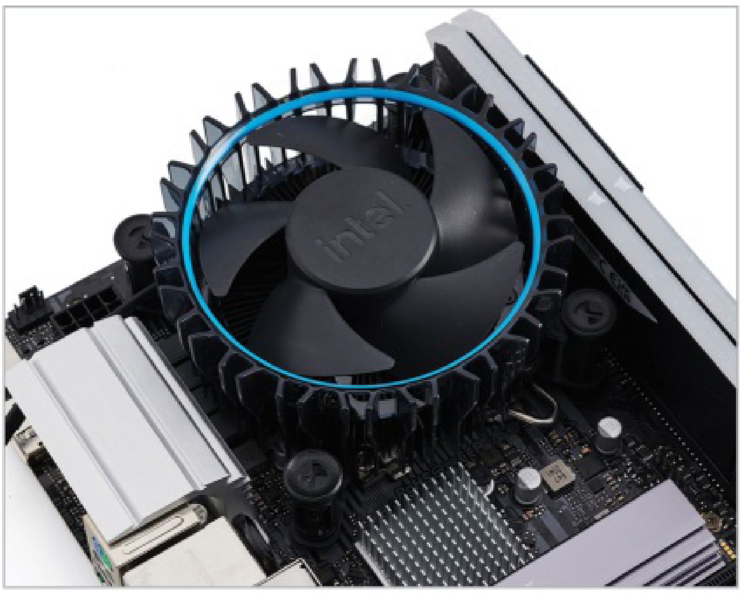
5 THE MEMORY BANK

AS THERE IS NO HEATSINK cover on this motherboard, it makes this process even easier too. No need to remove something that isn't there, of course. The M.2 port is exposed so all we need to do is take our SSD and insert it into the port at a 30° angle. Once in at this angle, we can lower it down and align the screw hole on the board with the one on the SSD. You'll need a small Phillips screwdriver and the M.2 screw from the motherboard box to then tighten this in place.



6 COOL LOOKING COOLER

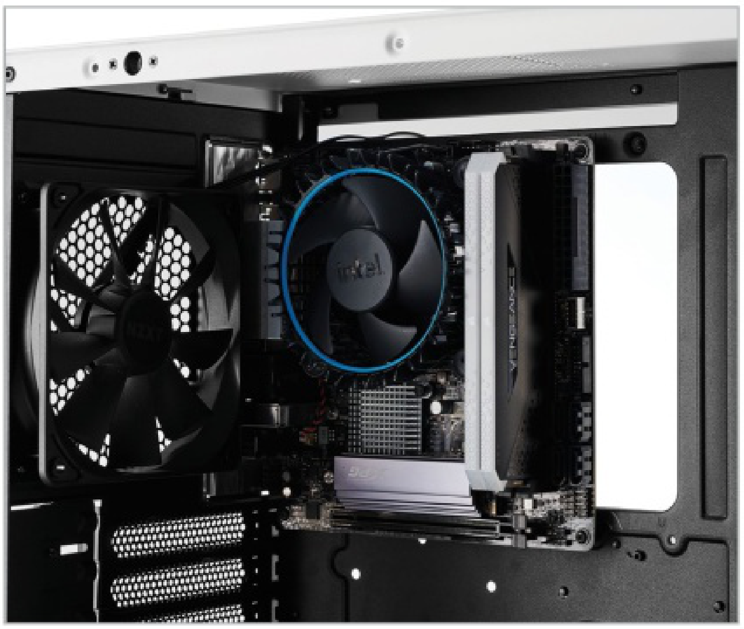
ON A SMALL BOARD like this, even an Intel stock cooler can look big. Thankfully, we have just enough clearance on our RAM sticks but if you use this motherboard, keep in mind that things can get tight when adding the cooler. Thankfully, this Laminar RM1 requires little preparation. No backplate is needed, as this cooler features just four pop-in clips. Working from one corner to the other diagonally, push these clip pins into the board to make sure it's secured. Always make sure to add a pea-sized amount of thermal paste onto the CPU before adding a cooler, otherwise, you might find yourself in trouble.



7

MOTHERBOARD INSTALL

NOW THAT THE MOTHERBOARD has all but the GPU installed onto it, we can pop this into our case. Before this, we need to add the I/O shield faceplate into the case—this fits without any tools or screws. Then we gently grab the motherboard and rest it down into the case, making sure the screw holes line up with the standoffs. Also, make sure the ports on the I/O align with the holes on the I/O faceplate too. Once you're happy, take the standoff screws and tighten the board down into the case using as many screws as you can.

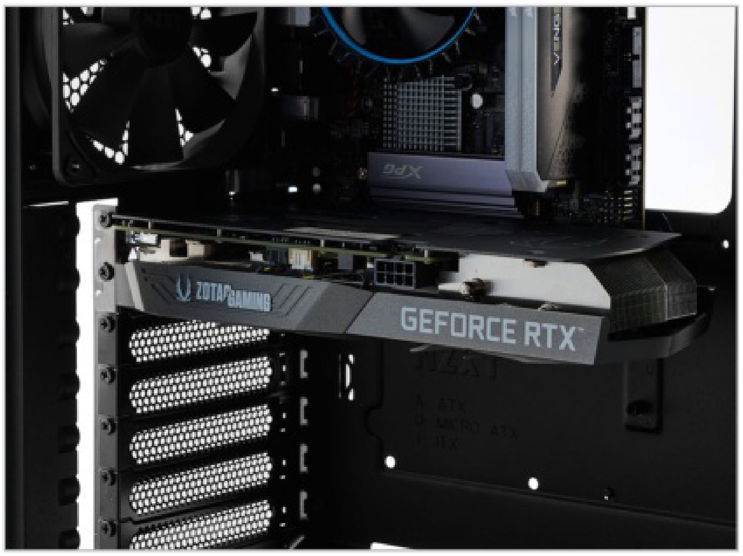


8

THE LAST COMPONENT

LAST BUT BY NO MEANS LEAST, we have to add our Zotac GeForce RTX 3050 card onto the board. This slots into the PCIe 4.0 slot underneath our SSD, but before we get to that, we need to make room for the GPU's ports. This involves removing two of the shrouds on the back of the case. There is one cover that unscrews and then you can get to the shrouds, which again require unscrewing to open up a space in the back.

We can then line up the GPU with this space and the PCIe port. Much like adding the RAM, we need to line up the notches, open the clip and slot it in place. It will make a satisfying click when it's in place.

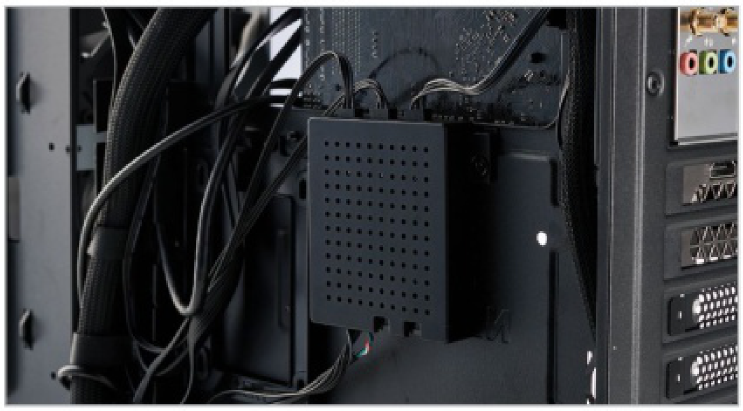


11

A SMALL HURDLE

WHEN PIECING all the final cables together, we realized that we were one fan header short on our motherboard to install all three of our NZXT case fans. We had two on the front sucking the air into the case, and one on the back acting as the exhaust fan. A quick rummage around our stock room and we found a spare NZXT fan controller hub from another case. A simple fan cable splitter would have been enough, but we had to work with what we had.

This was installed onto the back with a screw and hooked up to the power supply using the SATA connection. We took the three fan cables and connected them to this controller. There was another USB connection that went into the motherboard to finish this step. You can complete this build without the additional fan and controller—it wasn't exactly necessary, but we wanted a sleeker look for the front of the case and additional airflow.

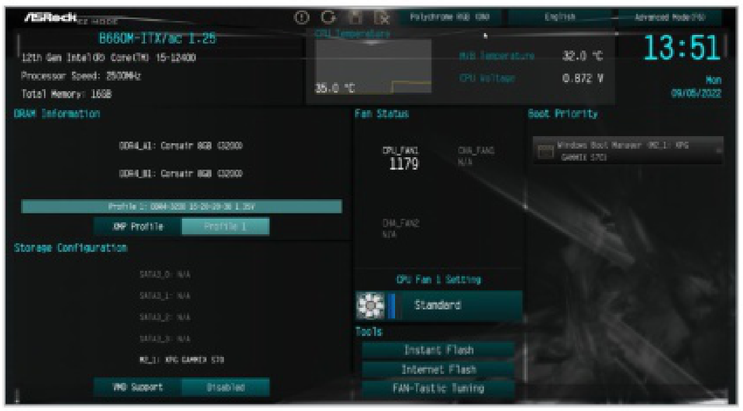


12

UPDATING THE BIOS

BY THIS POINT, your PC is now connected and you're close to getting the system up and running. To make sure everything's in check before putting all the panels back on, plug your PC in and make sure it turns on and the fans start spinning. All good? Then we can move into the software side of things. Luckily for us, our system booted straight into the BIOS.

To update this, download the latest BIOS version from the motherboard manufacturer's website using another system. Extract the ZIP files and save them onto a clean FAT32-formatted USB drive. Insert this into your PC, then head into the system's BIOS by mashing the delete key on boot up. Once in, go to the instant flash utility under the 'Tool' tab. Follow the on-screen wizard, select your file and let the computer do the work. After this, select 'exit saving changes' and there you have it.

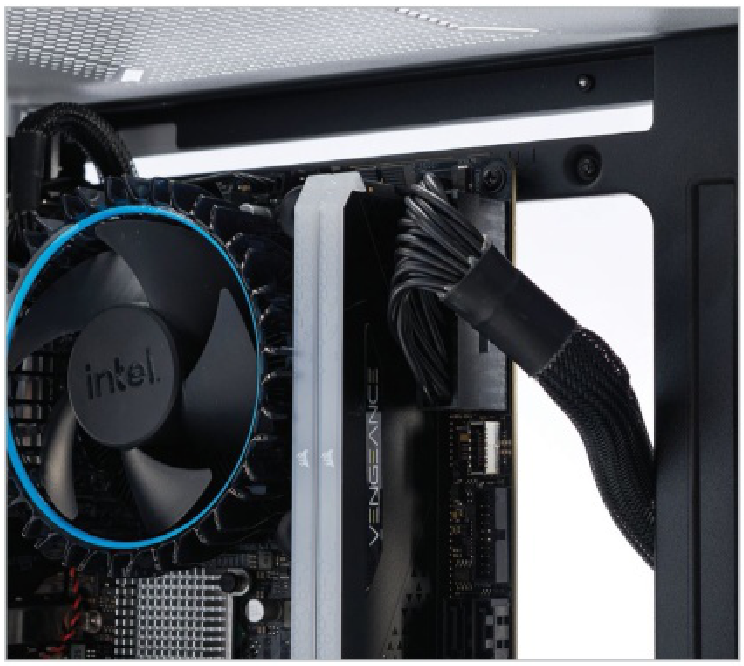


B660M-ITX/ac 1.25
12th Gen Intel(R) Core(TM) i5-12400
Processor Speed: 2500MHz
Total Memory: 16GB
CPU Temperature 35.0 °C
M/B Temperature 32.0 °C
CPU Voltage 0.872 V
13:51
Mon
09/05/2022
DRAM Information
DDR4_A1: Corsair 8GB C3200
DDR4_B1: Corsair 8GB C3200
Profile 1: DDR4-3200 16-20-20-38 1.35V
XMP Profile: Profile 1
Storage Configuration
SATA3_0: N/A
SATA3_1: N/A
SATA3_2: N/A
SATA3_3: N/A
M2_1: XPG GAMMIX S70
VMD Support: Disabled
Fan Status
CPU_FAN1 1179
CHA_FAN1 N/A
CHA_FAN2 N/A
CPU Fan 1 Setting: Standard
Boot Priority
Windows Boot Manager (M2_1: XPG GAMMIX S70)

© AS ROCK

9 POWER SUPPLY CONNECTIONS

TO GET THIS MACHINE running, we need to start connecting the dots. To begin with, we can connect our PSU cables to our motherboard. These include the 24-pin motherboard, CPU, and PCIe cables. They only go one way onto the board and then click down into place. The tightest one seems to always be the CPU, as that's on the top left-hand side of the motherboard. Thankfully, with this mini-ITX board, we have a bit more clearance than usual at the top so it makes life a little easier.



10 FRONT PANEL CABLES

AFTER THE PSU cables are in, it's time to connect the front panel cables to the motherboard. At this point, we always refer back to the manufacturer's manual on where to connect these cables. No matter how many PCs we've built, you can always count on one thing being different each time. And there's no shame in flicking through the instructions—that's what they're there for.

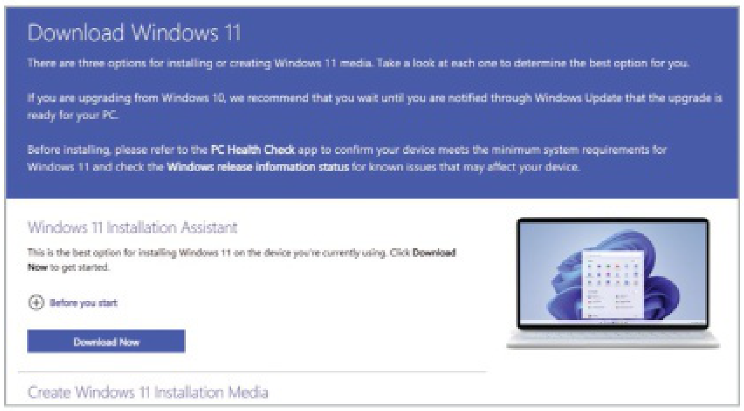
While you're connecting the dots, spend some extra time carefully choosing where to route your cables. Cable management will ensure your build is tidy and you won't be left with a heap of mess to untangle.

VENGEANCE
XPG

13 WINDOWS 11 INSTALL

FINALLY, WE NEED TO download and install a version of Windows 11 onto our PC. Again, using another system go to the official Microsoft site, head to the 'download Windows 11' page, and hit the download now button below where it says 'create Windows 11 installation media'. Make sure you have a clean USB drive formatted to FAT32 with at least 8GB of capacity. Then open up the installation Wizard and when it asks you where you want to install the media, select your USB drive and continue with the installation.

Once that's complete, take your USB drive and insert it into the new build and launch the BIOS. In the boot priority segment, ensure that your USB drive is at the top of the list, then select 'exit saving changes'. When your system reboots, it should load into the Windows 11 installation wizard and you can start setting up your new PC.



Download Windows 11

There are three options for installing or creating Windows 11 media. Take a look at each one to determine the best option for you.

If you are upgrading from Windows 10, we recommend that you wait until you are notified through Windows Update that the upgrade is ready for your PC.

Before installing, please refer to the **PC Health Check** app to confirm your device meets the minimum system requirements for Windows 11 and check the **Windows release information status** for known issues that may affect your device.

Windows 11 Installation Assistant

This is the best option for installing Windows 11 on the device you're currently using. Click **Download Now** to get started.

Create Windows 11 Installation Media

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techradar.

The home of technology

techradar.com

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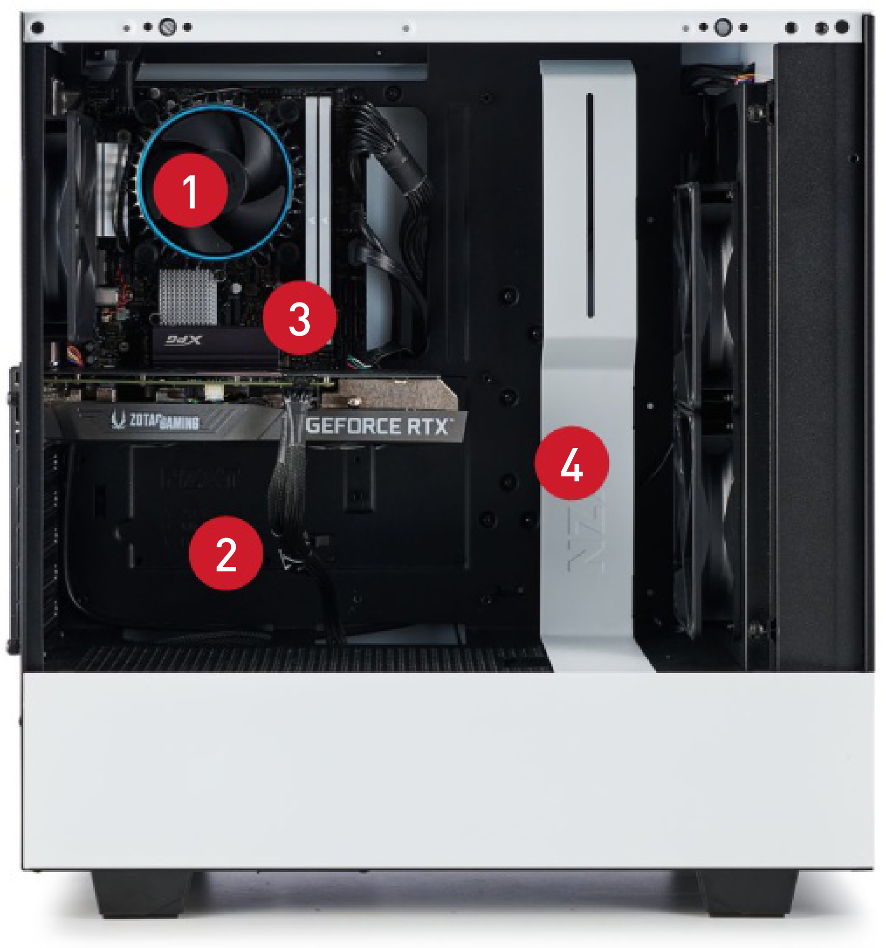


1 Thank you Intel for making stock coolers fashionable again—we really appreciate it. This Laminar RM1 suits the build perfectly.

2 Our GPU only required one PCIe cable, so we had to cable tie the excess connection away to make things tidier.

3 The only ray of light that comes from our build is via the Corsair Vengeance RGB RS RAM sticks. Squeezed next to the stock cooler, this was a rather tight fit though.

4 Using a mini-ITX board has left us with a lot of room in the case, which could be ideal for future upgrades.

VICTORY OR DEFEAT?

WE'LL GET STRAIGHT to the point here—piecing this budget machine together was a breeze. The only issue occurred when we got greedy and decided to add another fan to the build. Installing the fan itself wasn't the issue, but the problems arose when we tried to get it to work.

Although we enjoy using mini-ITX motherboards, the number of ports is restricted and we ran out of fan headers to connect it to. This meant we had to root around our stock room for a 3-pin fan splitter, which we didn't have. The next best thing was to borrow a fan controller from an NZXT H210i in a previous build. Don't worry though, this stage of the build was completely optional, we just weren't happy about leaving a fan-sized gap at the front of the case.

Aside from this minor hiccup, the build looks more premium than its budget might typically suggest. This is thanks to the NZXT H510 Flow case, especially in this black and white color combo. The black accent that sweeps around the case with its perforated grille on the front helps the case look modern and minimalist, a design that could fit into most setups. It's also not all about form, as this design offers a lot of functionality and increased airflow to the interior of the case, that's a win in our eyes.

That's all good, but does this sub-$1,000 machine perform as well as we'd hoped? We'd count this as a victory and not a defeat, as our machine holds up well. It falls short of our 1080p benchmark machine but that costs over $200 more. Looking at our benchmarking table, we achieve reasonable results for 1080p gaming. Averaging 45fps and above, a few tweaks could also improve them.

Of course, our benchmarks show you what it would run like using ultra settings but for 1080p gaming, but we'd recommend running on medium/high. This would mean you'd hit the sweet spot and achieve frames of around 70fps and above.

We haven't overclocked either, which could give a potential increase of around 5-10fps. In terms of other performance, the machine runs smoothly across a multitude of areas. Our CPU tests proved the i5-12400 is a capable budget chip, perfect for this machine. It works well in tandem with the Zotac GeForce RTX 3050 Twin Edge. Our SSD performed fantastically compared to our zero-point machine, topping off what has been a successful build at a low price.

BENCHMARKS

	ZERO-POINT	
Cinebench R23 Single-Core (Index)	1,537	1,675 (9%)
Cinebench R23 Multi-Core (Index)	10,632	11,735 (10%)
CrystalDisk QD32 Sequential Read (MB/s)	3,287	7,100 (116%)
CrystalDisk QD32 Sequential Write (MB/s)	2,419	6,755 (179%)
3DMark Fire Strike Extreme (Index)	24,814	14,260 (-43%)
Cyberpunk 2077 (fps)	68	49 (-28%)
Cyberpunk 2077 RTX (fps)	18	28 (56%)
Metro Exodus (fps)	75	44 (-41%)
Metro Exodus RTX (fps)	52	33 (-37%)
Total War: Three Kingdoms (fps)	72	63 (-13%)
		0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our 1080p zero-point consists of an AMD Ryzen 5 5600X, an XFX Speedster QICK308 Radeon RX 6600 XT, an Asus ROG Strix B550-F WiFi, 16GB of XPG Gammix D45 DDR4-3200, and a 1TB ADATA Legend 840. All games tested at 1080p 'Ultra' graphics presets with DLSS/FSR and V-sync turned off. XMP/AMP for RAM speed turned on in all tests. No manual CPU overclocking.

PREPPING YOUR FRESH PC

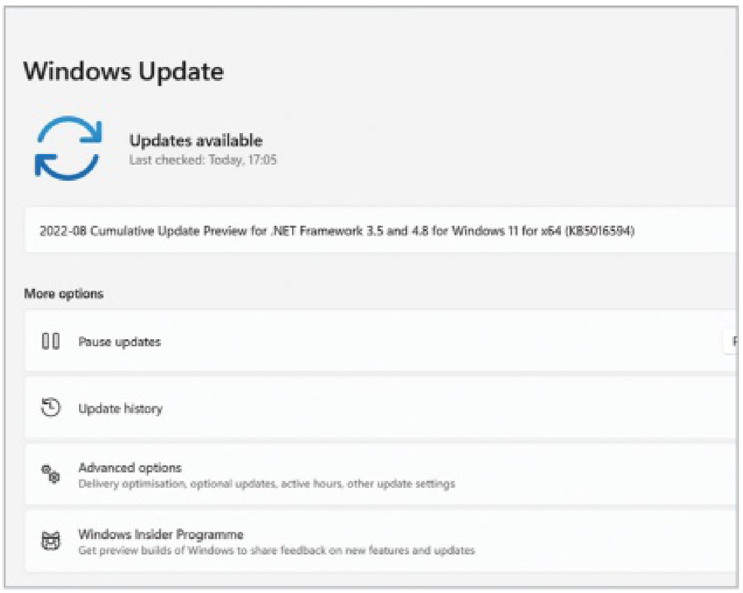
Follow these steps to make sure your PC is running up to speed

TO HELP YOU GET the most out of your fancy new computer, there are a few things you can do. Unfortunately, building a PC isn't quite the same as buying a smartphone, for example, where pretty much everything is all set up and ready for you to start. Before you can start powering through *Halo Infinite* on Legendary, we need to sort out the latest updates, drivers, settings, and more. Sure, we could dive straight in and start running games, but we're on a budget and with all of the resources here, it would be a shame if they weren't being maximized.

1

UPDATE YOUR SHIP

ONCE YOU'RE DONE building your machine and you've established a stable internet connection, you can start off by updating your system. This is an easy way of ensuring that your PC is fully optimized and running the latest stable version of Windows. To do so, head over to the start menu, then settings. On the left-hand side at the bottom, you'll find Windows Update. Click here and hit the check now button to find the latest updates. Download these then install them and restart your PC. Additionally, you can find optional updates in the advanced options menu on the Windows Update page.



Windows Update

Updates available
Last checked: Today, 17:05

2022-08 Cumulative Update Preview for .NET Framework 3.5 and 4.8 for Windows 11 for x64 (KB5016594)

More options

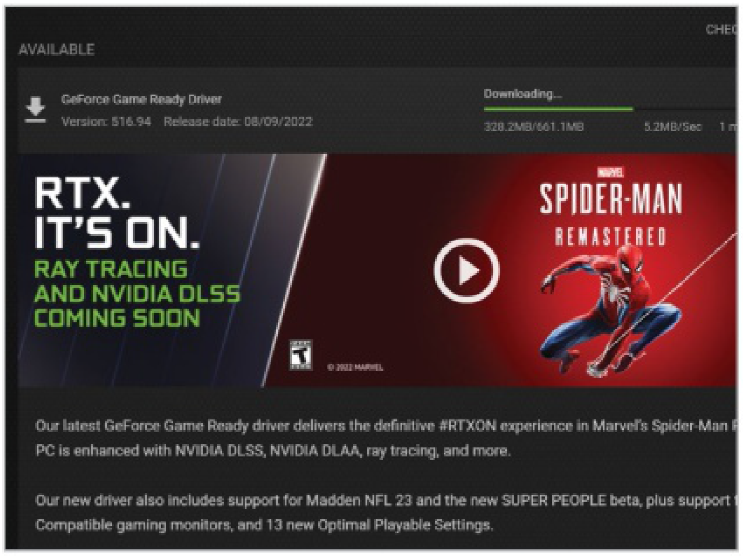
Pause updates
Update history
Advanced options
Delivery optimisation, optional updates, active hours, other update settings
Windows Insider Programme
Get preview builds of Windows to share feedback on new features and updates

4

NVIDIA GEFORCE EXPERIENCE

ANOTHER NVIDIA application to check out is GeForce Experience. As well as being a great games launcher, you're going to need it to download and update your graphics card drivers. In the app, go to the Driver tab and click 'check for updates'. Follow the on-screen prompts to install it.

In the settings, also make sure you have 'in-game overlay' turned on. Then, when you're in a game, press 'ALT+Z' to open this. Within the overlay, click into the performance tab and turn on 'enable automatic tuning'. This should again boost your performance and hopefully give you a few more frames when gaming.



AVAILABLE

GeForce Game Ready Driver
Version: 516.94 Release date: 08/09/2022

Downloading...
328.2MB/661.1MB 5.2MB/Sec

RTX.
IT'S ON.
RAY TRACING
AND NVIDIA DLSS
COMING SOON
SPIDER-MAN
REMASTERED

Our latest GeForce Game Ready driver delivers the definitive #RTXON experience in Marvel's Spider-Man
PC is enhanced with NVIDIA DLSS, NVIDIA DLAA, ray tracing, and more.

Our new driver also includes support for Madden NFL 23 and the new SUPER PEOPLE beta, plus support
Compatible gaming monitors, and 13 new Optimal Playable Settings.

© MICROSOFT, NVIDIA

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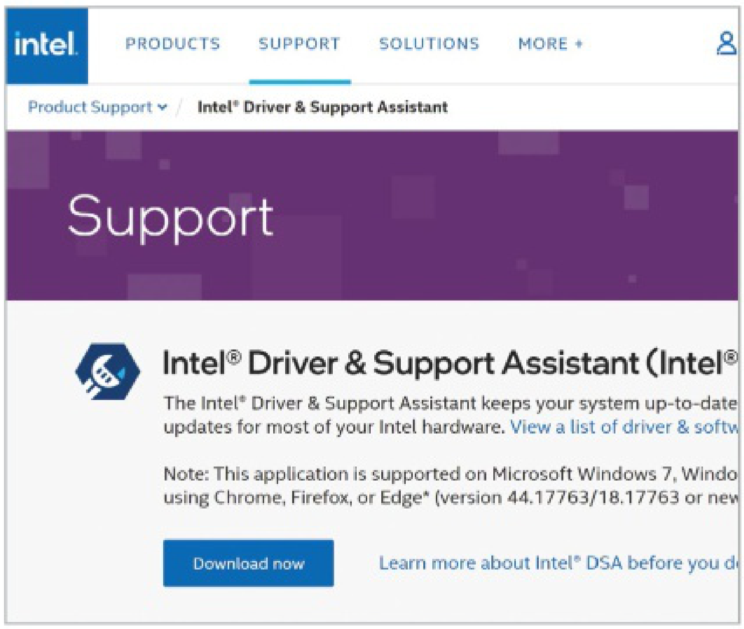
2

INTEL DRIVER & SUPPORT ASSISTANT

AFTER UPDATING your system to the latest version of Windows 11, you can move on to drivers. On your chosen web browser, head over to www.intel.com and download the Intel Driver & Support Assistant. This nifty tool will help make sure that all your relevant drivers, including Wi-Fi, and Bluetooth, are up to date. This is an easy one-stop place for your Intel drivers, so all you need to do is follow the on-screen prompts to get things started. After installing new software, we'd recommend that you do a quick restart of your system.


intel.
PRODUCTS
SUPPORT
SOLUTIONS
MORE +
Product Support
Intel® Driver & Support Assistant
Support

Intel® Driver & Support Assistant (Intel®

The Intel® Driver & Support Assistant keeps your system up-to-date
updates for most of your Intel hardware. View a list of driver & softw

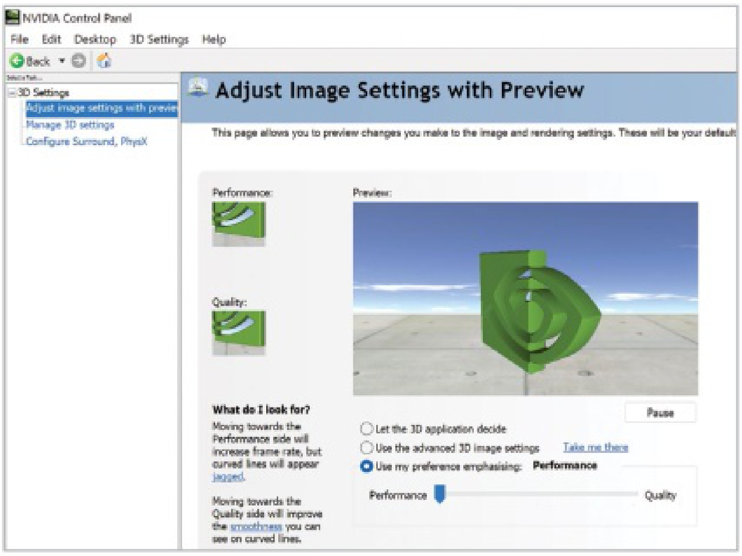
Note: This application is supported on Microsoft Windows 7, Windo
using Chrome, Firefox, or Edge* (version 44.17763/18.17763 or new

Download now
Learn more about Intel® DSA before you d

3

NVIDIA CONTROL PANEL

IF YOU'VE GOT an Nvidia GPU, like the RTX 3050 we have in this build, then you need to install the Nvidia control panel. You can download this from the Microsoft web store. This application will allow you to fine-tune your graphic driver settings in relation to your image and 3D options. On the landing page of the Nvidia control panel, you should be greeted by the 'adjust image settings with preview' page. To squeeze some more frames out of your system, we recommend taking a small hit on image quality by moving the slider to the performance end. To do this the option 'use my preference' needs to be selected, then make the change and hit apply.


NVIDIA Control Panel
File
Edit
Desktop
3D Settings
Help
Back
3D Settings
Adjust image settings with previe
Manage 3D settings
Configure Surround, PhysX
Adjust Image Settings with Preview
Performance:
Preview:
Quality:
Pause
Take me there
Performance
Quality

This page allows you to preview changes you make to the image and rendering settings. These will be your default

What do I look for?

Moving towards the Performance side will increase frame rate, but curved lines will appear jagged.

Moving towards the Quality side will improve the smoothness you can see on curved lines.

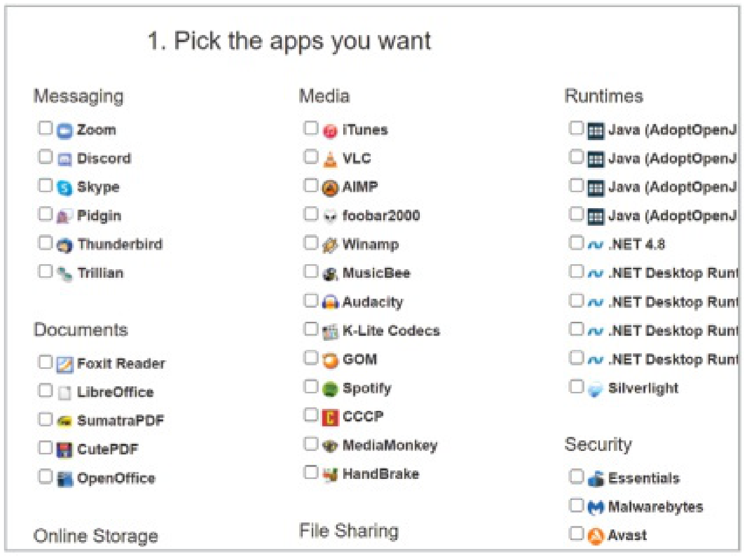
○ Let the 3D application decide
○ Use the advanced 3D image settings
● Use my preference emphasising: Performance

5

NINITE

LOOKING FOR ONE PLACE to go where you can grab all of your favorite applications? Then you've come to the right place. We've used Ninite for what feels like an eternity now, because it does exactly what it says on the tin. Ninite is a simple service that lets you choose exactly what applications you want from a long list, saving you going round all the relevant websites manually.

To make life even easier, apps are also split into categories. So, check which ones you need then scroll down and click 'get your ninite'. This will then run an installer in the background and download all the applications you have picked. It's as simple as that.



1. Pick the apps you want

Messaging
☐ Zoom
☐ Discord
☐ Skype
☐ Pidgin
☐ Thunderbird
☐ Trillian

Documents
☐ Foxit Reader
☐ LibreOffice
☐ SumatraPDF
☐ CutePDF
☐ OpenOffice

Online Storage

Media
☐ iTunes
☐ VLC
☐ AIMP
☐ foobar2000
☐ Winamp
☐ MusicBee
☐ Audacity
☐ K-Lite Codecs
☐ GOM
☐ Spotify
☐ CCCP
☐ MediaMonkey
☐ HandBrake

File Sharing

Runtimes
☐ Java (AdoptOpenJ
☐ Java (AdoptOpenJ
☐ Java (AdoptOpenJ
☐ Java (AdoptOpenJ
☐ .NET 4.8
☐ .NET Desktop Runt
☐ .NET Desktop Runt
☐ .NET Desktop Runt
☐ .NET Desktop Runt
☐ Silverlight

Security
☐ Essentials
☐ Malwarebytes
☐ Avast

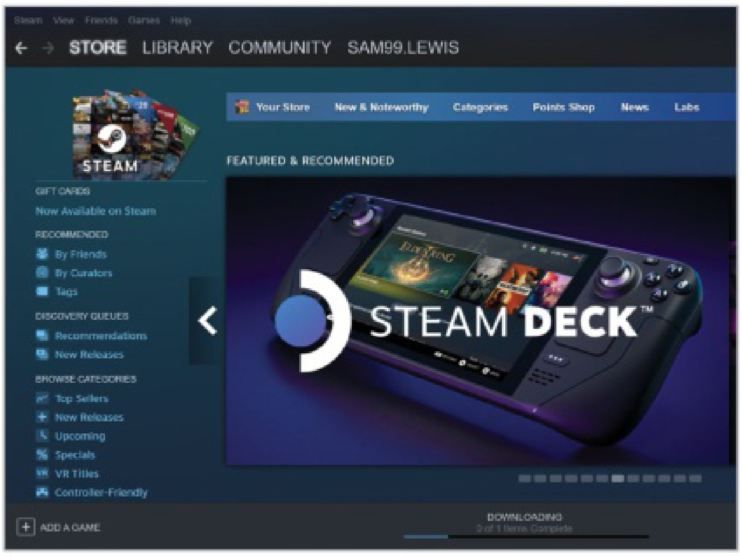
6

STEAM ME UP, SCOTTY

WE PRESUME that you ticked the box for Steam when choosing your ninite applications. Of course you did! It's an essential app for gaming on a PC—home to most of the games you'll ever need and with a library longer than the Mississippi River, though don't quote us on that.

If you're more of a controller-based gamer, then take advantage of Steam's Big Picture mode. This essentially turns the interface into more of a console-inspired design, which works perfectly with a controller.

If you've followed all the steps above, you should now be ready to download some of your favorite titles and get cracking into some smooth 1080p gaming.


Steam
View
Friends
Games
Help
STORE
LIBRARY
COMMUNITY
SAM99.LEWIS
Your Store
New & Noteworthy
Categories
Points Shop
News
Labs
STEAM
FEATURED & RECOMMENDED
GIFT CARDS
Now Available on Steam
RECOMMENDED
By Friends
By Curators
Tags
DISCOVERY QUEUES
Recommendations
New Releases
BROWSE CATEGORIES
Top Sellers
New Releases
Upcoming
Specials
VR Titles
Controller-Friendly
STEAM DECK™
ADD A GAME
DOWNLOADING

© INTEL, NVIDIA, NINITE, STEAM

STARTER PERIPHERALS

TO HELP YOU get into the swing of things, you're probably going to need more than just your new budget-build PC. A decent set of peripherals should ensure that you can get the most out of your system.

And because we're on a tight budget, we've lined up a few budget items to get you started. These will allow you to enjoy your new PC in all its glory, but won't necessarily break the bank, including a mouse, keyboard, webcam, headset, and microphone. That's enough gear to get started gaming—and streaming some content, if that's up your street.

QHD 2K HDR
FHD 1080P/60fps
AUSDOM

AUSDOM AW651 HDR 2K WEBCAM $90

Having a blurry, pixelated image when joining a video call, recording a video, or live streaming is one way to make your setup look unprofessional—but a high-quality webcam can easily fix this. First impressions count, especially in a video interview or work-related setting, so having a crisp image shows that you care about how you present yourself.

Ausdom's AW651 HDR 2K webcam comes in at ten bucks short of $100 and provides clear and smooth video. Boasting a resolution of 1440p at 30fps or 1080p at 60fps, it's all you need to keep your videos bright and detailed.
www.ausdom.com

MSI IMMERSE GV60 STREAMING MIC $130

This is a microphone that will last. Featuring a range of recording modes, you'll find a use for this, whether you're gaming, in a video meeting, or recording a podcast. The build quality is fantastic and follows a more professional design than MSI's typical styling. The GV60 is a super-easy microphone to use as it's plug-and-play. Settings are changed directly on the microphone, meaning you can switch between recording modes on the fly. Above all, the crystal clear recording quality offered by MSI, makes this a great buy.
www.msi.com

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CORSAIR HS65 SURROUND $80

For a sub-$100 headset, this Corsair HS65 Surround headset can do most of what you need, and do it well. It features a premium design for the money, especially in the sleek white color scheme with chrome accents. There's a foldable microphone that offers clear pickup, perfect for party chats and zoom calls. Connectivity is limited as the headset connects via a 3.5mm auxiliary cable, but if this isn't a dealbreaker, you can get a warm-sounding headset for a sensible price.

www.corsair.com

WHIRLWIND FX ATOM

$80

Your next biggest connection between you and your PC is through your keyboard, so it's another important decision. There are so many options when it comes to keyboards that it's difficult to find the perfect one.

However, a good starting point is the Whirlwind FX Atom for just under $80. This wired 60 percent keyboard is a slimmed-down version of the Element V2 board that ditches the arrow keys, numeric pad, and function keys for a sleeker experience.

Preferred by gamers, this durable RGB board has a high polling rate and features Gatreon switches—on our review unit, these were the Linear Red variety. A good range of features, high build quality, and respectable price make this a great keyboard for your new budget PC.

www.whirlwindfx.com

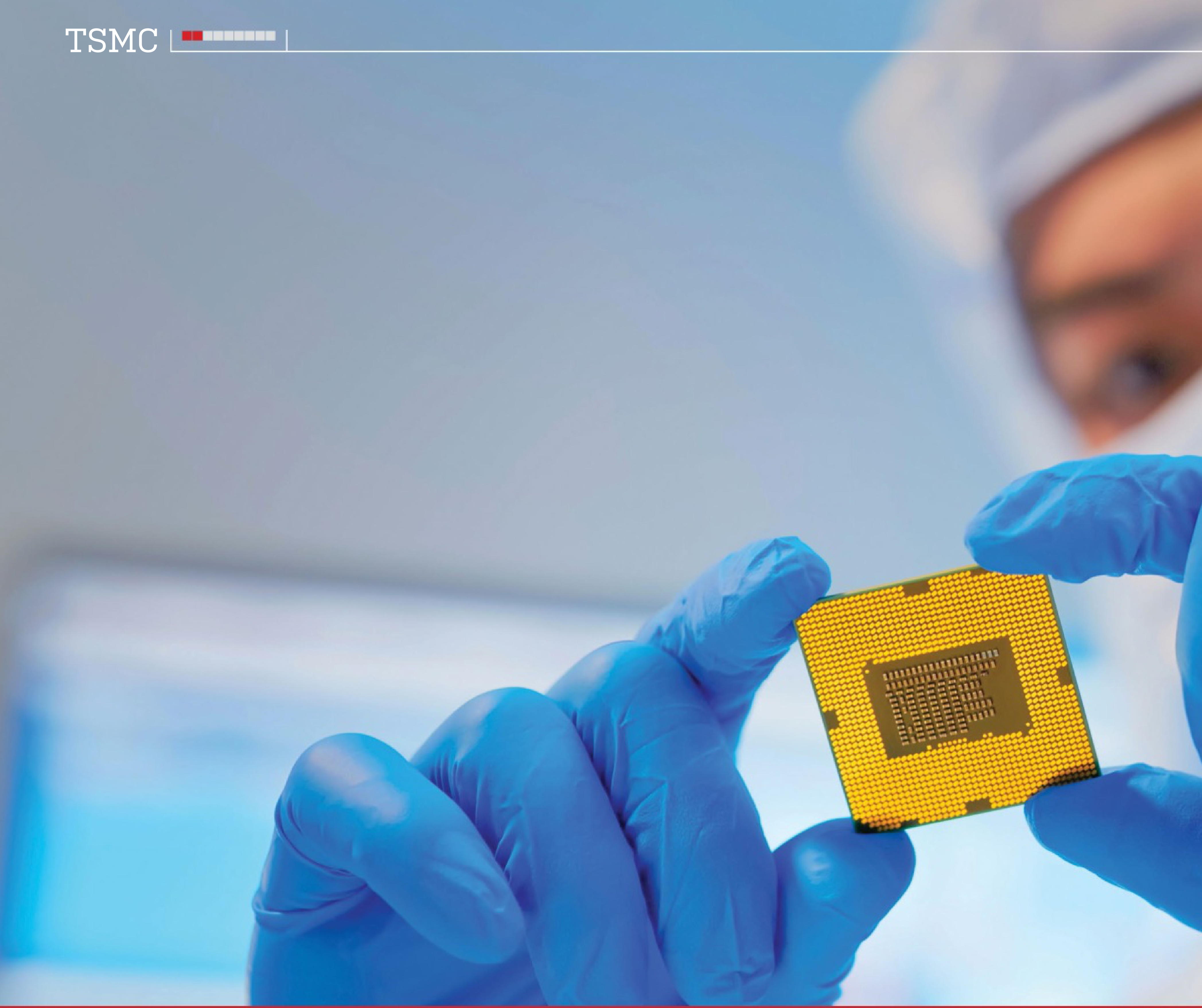
ENDGAME GEAR XM1 RGB WHITE MOUSE $70

The most frequent connection between you and your PC is through your mouse, so choosing the right one is an important decision to make.

Thankfully, there are plenty of mice available at the budget end of the market that not only offer great performance but also look stylish, one of which is the Endgame Gear XM1 RGB. Although it's not wireless, it's a lightweight mouse with a lightweight cable for reduced drag.

It glides smoothly and, with an adjustable polling rate, it's perfect for gaming. The design is sleek too, without excessive RGB lighting.

www.endgamegear.com



HOW TSMC CAME TO

A decade ago, TSMC was generations behind Intel in chip production technology but now it's the undisputed world leader. ***Jeremy Laird*** looks at the rapid rise of Taiwan's chip foundry

MADE IN
TAIWAN

RULE THE WORLD

© GETTY IMAGES/ PONYWANG, EXTRACOIN

JUST SEVEN OR EIGHT YEARS AGO, it was multiple generations behind Intel in chip production technology. 15 years ago, it was a bulk producer of cheap commodity chips with no track record in high-performance silicon, and 30 years ago, it barely existed. So, how has TSMC come to rule the world?

Today, TSMC can claim indisputable world leadership in chip manufacturing with at least one generational advantage over Intel, arguably two. It produces roughly half of the global supply of customer-designed chips and over 90 percent of those manufactured on cutting-edge processes. Its chips go into not just PCs and phones, but cars, military equipment, medical hardware, and everything else we depend on these days.

TSMC is based in Taiwan, an island territory operating as a de facto independent state without being formally recognized as such by the international community. For the past 50 years or so, China has viewed Taiwan as a rogue element and has officially maintained the unilateral right to repossess the island. As far as China is concerned, it and Taiwan remain a single nation.

Modern life as we know it depends to a large extent on the output of a single company based in a country that sort of doesn't exist, itself situated on an island separated from China by a sliver of water that might just be the most dangerous place on Earth. How, exactly, did we get here and what does the future hold?

IF YOU'RE A TECH fanatic of a certain vintage, viewing everything through the prism of the PC, you'll probably be familiar with TSMC. But you'll also instinctively think of it as something of a budget outfit, operating slightly behind the curve. Sure, TSMC was critical—it enabled the creation of important PC components, such as graphics chips. Neither Nvidia nor ATI (before the latter was acquired by AMD) produced their own chips. They designed them, of course, but paid third parties, and often that was TSMC, to do the manufacturing honors.

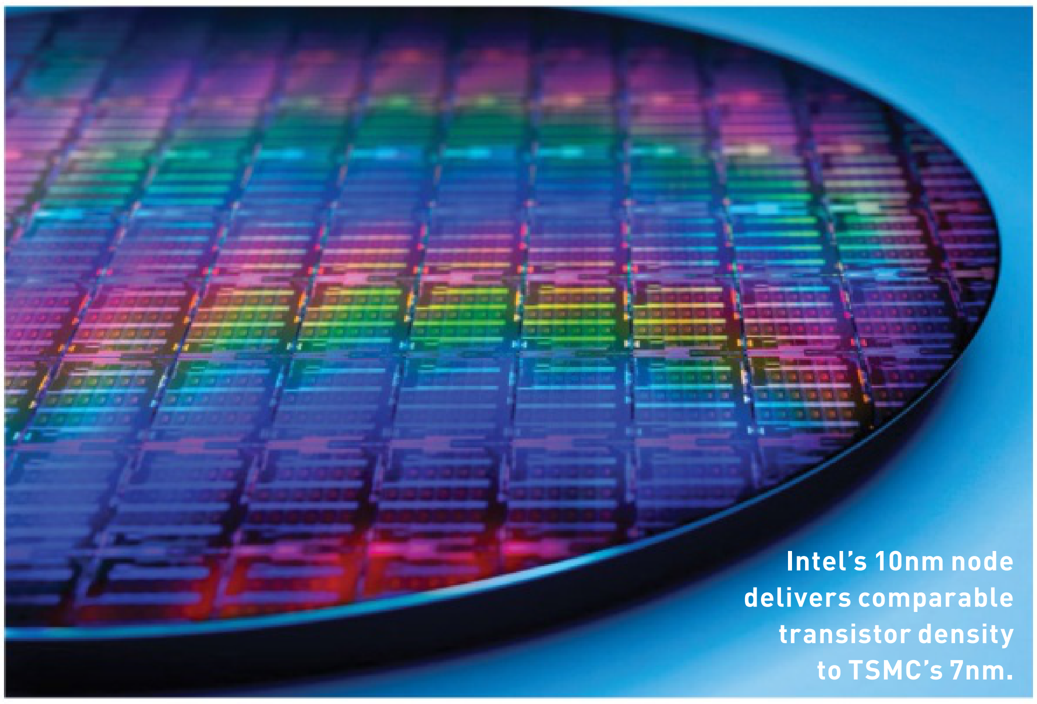
So, TSMC mattered. But GPUs historically did not require the absolute best in chip production technology. Decent transistor density was certainly desirable. But GPUs were not designed for and did not demand the last word in clock frequencies, typically running at a third or less of the speed of contemporary CPUs. In short, TSMC simply didn't compare with Intel when it came to the fine art of turning sand into ultra-high-performance silicon.

For AMD, increasingly that was a problem. AMD had been forced to spin off its own chip production facilities, also known as fabs or foundries, in 2009 in an attempt to keep the company alive. Building new fabs is a multi-billion dollar enterprise and AMD simply didn't have the cash. The idea was that selling off its existing fabs would give AMD a desperately needed cash injection while allowing the newly independent manufacturing unit to acquire external customers and outside investment, both of which would bankroll the next-gen production units needed to keep up with Intel's world-beating fabs.

The logic was sound, GlobalFoundries was soon the third-ranked foundry in the world and AMD got its cash. Unfortunately, the technology half of the grand plan didn't work out quite so well. By 2010, Intel's 32nm chip production node was full steam ahead with 22nm arriving the following year. Meanwhile, GlobalFoundries was struggling to get its own 32nm tech working at all. As a consequence, AMD's first quad-core 32nm CPU, codenamed Llano, was delayed until late 2011.

AMD realized it needed to at least think about alternatives to GlobalFoundries.

MY NM IS BETTER THAN YOUR NM


Intel's 10nm node delivers comparable transistor density to TSMC's 7nm.

© INTEL

On paper, it seems as though TSMC is miles ahead of Intel. After all, it's been over two years since the first commercially available devices powered by 5nm TSMC chips hit the market. Meanwhile, as we went to press, TSMC is just weeks away from mass production of 3nm chips. And Intel? Its most advanced node for commercial chips is 10nm. Oh dear!

But hold on. Making assumptions based on the nomenclature involved is problematic. Put another way, TSMC's nanometers are not directly comparable to Intel's. How can that be possible? The name attached to a given process node has become detached from the physical reality of the chips involved. It used to relate to the smallest feature inside a chip. Now node naming is more branding and marketing than science.

In the end, what matters is transistor density or the number of transistors any process node can cram into a given area of silicon wafer. More transistors mean more features and performance, while smaller transistors use less power. It's a win-win as feature sizes shrink. Such are the advances in that regard, current process nodes are measured in a barely comprehensible metric of hundreds of millions of transistors per square millimeter. Yup, completely crazy.

Anyway, when you compare transistor density, it quickly becomes clear that TSMC's advantage over Intel isn't quite as overwhelming as that 10nm versus 5nm or even 3nm comparison implies. Intel's 10nm node delivers just over 100 million transistors per square millimeter, while TSMC's 10nm clocks in at 53 million. Indeed, TSMC's 7nm node is only good for 97 million transistors per millimeter squared. Suddenly, Intel's rebranding of its 10nm node to 'Intel 7' seems pretty reasonable.

Of course, TSMC has been making chips on its own 5nm for a couple of years. TSMC 5nm boasts a density of 173 million transistors, well ahead of Intel 10nm.

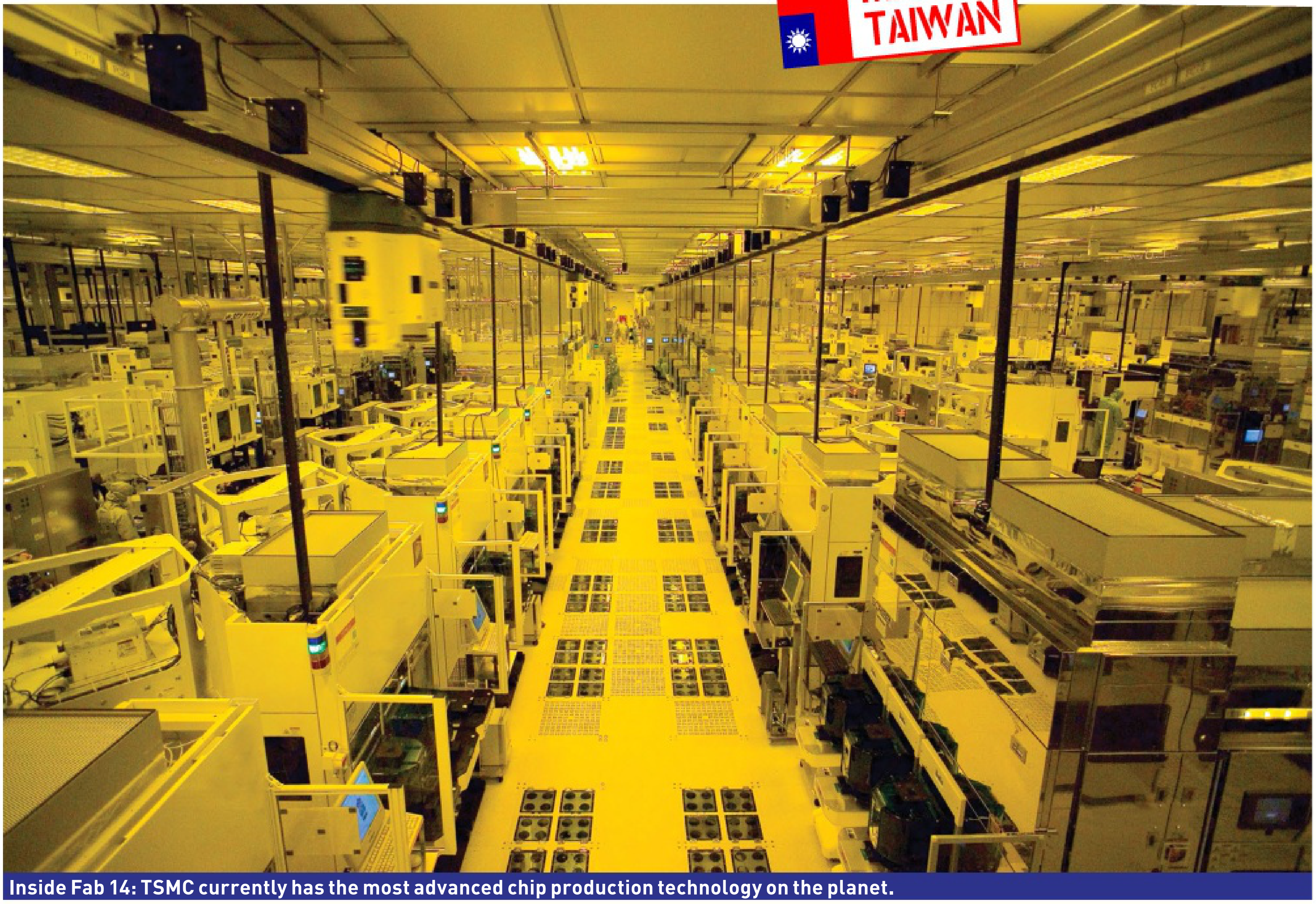
Meanwhile, TSMC 3nm will up that to a hefty 290 million. Even if Intel manages to get its new 7nm node, branded Intel 4, going next year, it will only edge ahead of TSMC 5nm with 180 million transistors per millimeter squared, placing Intel three years behind TSMC for transistor density.

As for Samsung, its 10nm node was comparable with TSMC for density. But since then it has fallen behind. And what about the new 3nm node that Samsung proudly announced was already in mass production earlier this summer? It's actually slightly less dense than TSMC 5nm.

As for whether Intel can catch up, well, that's the million dollar—or should that be transistor—question. Intel's 5nm tech, which will be marketed as Intel 20A where the 'A' stands for angstroms, isn't due until at least 2024, putting it 18 months behind TSMC at minimum. Intel's 3nm node, the branding for which hasn't been announced, is expected to deliver a staggering 520 million transistors per millimeter squared, slightly ahead of TSMC's 2nm which is forecast to hit 490 million.

If TSMC and Intel both hit their targets, we can expect 2nm TSMC chips in 2025 and Intel closing the gap to just one year with its 3nm process in 2026. And that's a best-case scenario for Intel. It's a long road back, that's for sure.

MADE IN TAIWAN


Inside Fab 14: TSMC currently has the most advanced chip production technology on the planet.

So it turned to TSMC, a company not then known for process nodes capable of supporting high-frequency CPUs. The first 'GloFo' chip of that era, a dual-core APU known as Ontario, was on TSMC's 40nm node and went largely under the radar. Over the next few years, GlobalFoundries got its act together with Samsung's help to create a reasonably competitive 14nm node for 2015. Both the original Ryzen 1000 Series and the Ryzen 2000 follow-up were built on that 14nm tech. But it was a temporary stay of execution rather than a long-term solution. In 2018, GloFo announced that development of its next-gen 7nm node was on indefinite hold. GlobalFoundries was, to all intents and purposes, bowing out of the bleeding-edge chip production race.

STRATEGIC ALLIANCES

AMD now desperately needed to turn that earlier experimentation with TSMC into a full-blown strategic alliance. And so it was TSMC that got the nod for the Ryzen 3000 series based on the Zen 2 architecture. In hindsight, it seems like the rest is history. But even then, as recently as 2018, betting everything on TSMC being capable of delivering on those critical clock speeds seemed like a serious gamble. There was little hard evidence then that TSMC could produce CPUs running at speeds of well over 4GHz plus, the sort of frequencies AMD would need to take on Intel.

As it turned out, TSMC could. And then some. Those first TSMC-produced Ryzen CPUs ran at up to 4.7GHz, thanks to TSMC's latest 7nm node. Any remaining doubts over the Taiwanese foundry's ability to compete at the bleeding edge vanished. Indeed, AMD has just announced the Ryzen 7000 series will hit 5.7GHz, courtesy of TSMC's leading-edge 5nm tech. There can no longer be any doubt that TSMC can deliver both density and speed.

While all that was happening, Intel was going through perhaps the most troubled period of its entire existence, with the chronic failure of its own fabs to hit process node targets. The net result of which was that Intel's 10nm node was at least five years late, a veritable eon in the chip industry. Even today, it still hasn't fully transitioned to 10nm technology, while TSMC has been cranking out 5nm chips for years and is just about to mass produce 3nm products.

Of course, Intel and TSMC's production nodes aren't directly comparable. As you can see in the boxout opposite, Intel's 10nm or 7nm technology is very different from TSMC nodes of the same name. But by most objective measures, Intel is somewhere between one and two full generations of chip production technology behind. TSMC's advantage is so acute, that AMD's CEO Lisa Su was recently able to showcase how the latest Zen 4 CPU cores in the new Ryzen 7000 series processors are half the size of Intel's latest Alder Lake cores. For Intel, that has got to hurt.

If that's a potted history of TSMC's rise viewed through the aforementioned PC prism, it's only a small part

Taking the contract for Apple iPhone chip production away from Samsung has arguably been TSMC's greatest achievement.

© APPLE CORP, TSMC

of the broader picture of how TSMC came to dominate chip production and become arguably the most important company in the world. To get a better idea of just how monumental TSMC's importance has become, let's put some numbers on it all.

TSMC was founded in 1987 by ex-MIT and Texas Instruments alumni, Morris Chang.

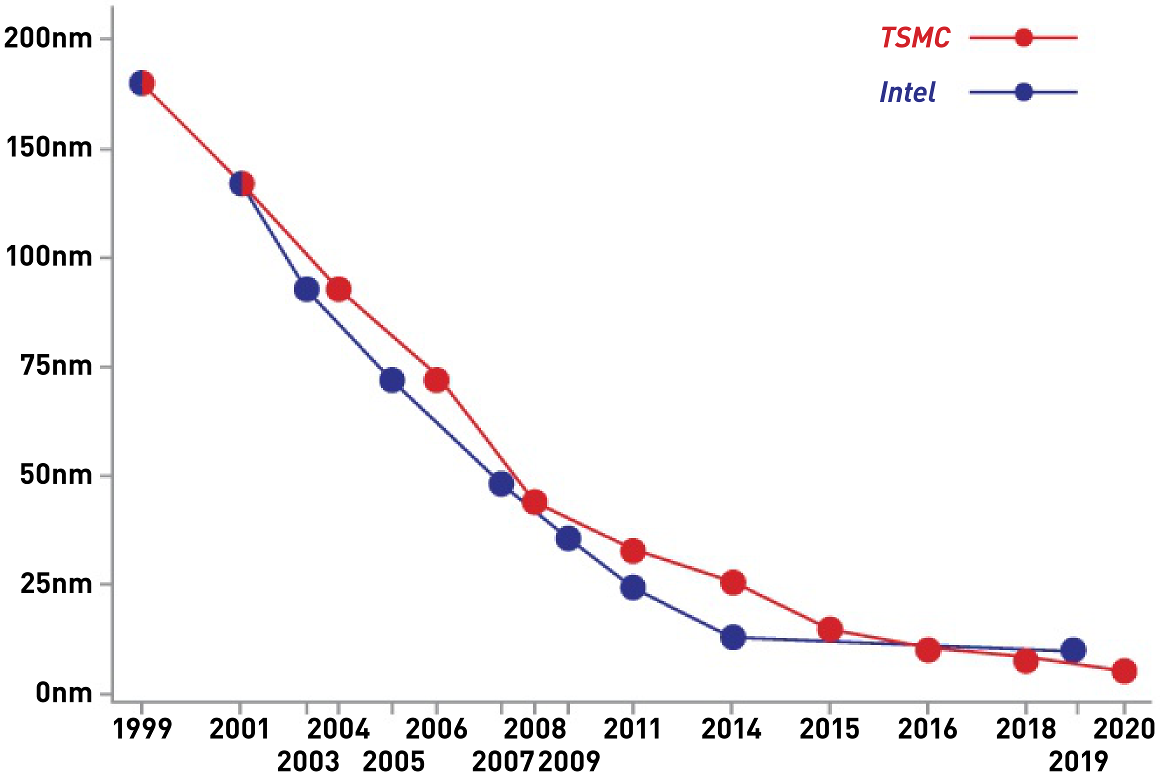
MAKING THE WORLD GO ROUND

According to market research firm Trendforce, in the first quarter of this year, TSMC generated over $17 billion in foundry revenues. That represents fully 53.6 percent of the total global market in manufacturing chips for customers. Think about it. That's over half of the chips that go into everything that relies on integrated circuits. So, not just PCs, laptops, tablets, and phones. But also TVs, cars, domestic appliances, medical equipment, military hardware, telecoms kit, the works. In other words, pretty much everything that makes the modern world go round. And over half of it depends on the output of a single company: TSMC.

Samsung is next in line with a little over $5 billion in foundry revenues, with UMC third at $2 billion in revenues. Remember GlobalFoundries, the foundry business AMD spun off back in 2009? It comes fourth with just under $2 billion in revenues. Of course, those figures relate to all manner of chips, from cutting edge to commodity chips on legacy processes.

GlobalFoundries, as explained, has pretty much given up trying to keep up with Moore's Law and the rest of the industry, preferring to stick with 14nm and above technology. So, if you break market share down into more finely-grained categories based on specific process nodes, TSMC looks ever more dominant as you approach the cutting edge. In 2020, TSMC owned around 90 percent of the sub-10nm market, with Samsung its only competitor. Even in the 32nm to 12nm space, it had 70 percent of the market. You have to go to 45nm and larger before TSMC's market share drops below 50 percent.

NODE TO NODE



A timeline of TSMC versus Intel process nodes

It wasn't always this way. Twenty years ago, there were as many as 20 foundries that could plausibly compete in terms of process node technology. Now there is only TSMC and Samsung, with Intel planning to get in on the action as a customer foundry itself (see boxout page 38) and possibly IBM re-entering the fray with a future 2nm node. The reason is the monumental cost of the most advanced chip manufacturing technology. In 2021 alone, TSMC invested over $25 billion in new facilities. Its latest 3nm fab currently being constructed in Shanhua, Taiwan, covers 160,000 square meters—about the same size as 22 football fields.

© TSMC

Of course, TSMC will need more than one 3nm fab in the long run. And if it is to maintain its leadership position, it must then create a new generation of production facilities for the jump to 2nm for 2025, or thereabouts. And on, and on. Very likely, TSMC will invest in excess of another $100 billion in advancing its production capabilities before the decade is out. These are preposterously big numbers by any metric. And that's why it will be so hard for anyone, including Intel, to unseat TSMC at the top any time soon.

All of which begs the question of how TSMC got into the position to invest on that epic scale in the first place. It all started in 1985 when a Chinese-born engineer named Morris Chang was recruited by the Taiwanese government to overhaul its technology strategy. Chang, who had studied at both MIT and Stanford, was a 25-year veteran of none other than Texas Instruments and undoubtedly a leading expert in commercializing semiconductors. In 1987, Chang founded TSMC with funding from the Taiwanese government as a major shareholder, but

Is TSMC's 3nm tech in trouble?

THE TROUBLE WITH 3NM

If this so far has largely been a tale of glorious success for TSMC, is that a dark cloud we can make out on the horizon?

We speak of TSMC's upcoming 3nm node. It has been widely reported that 3nm has been problematic for TSMC. Blame the pandemic? It could be a factor. Or is it more that TSMC is sticking with existing FinFET or fin field-effect transistor tech while the competition is moving to more advanced GAAFET or gate-all-around field-effect transistors? Either way, there are a few signs that TSMC 3nm isn't quite on track.

For evidence, we refer you to TSMC's own relentless march of new production nodes. In fall 2018, you could buy an actual consumer product containing a chip produced on TSMC's 7nm node. By the same time in 2020, there were products with 5nm TSMC chips. Well, here we are in the second half of 2022, so that means phones and laptops with TSMC 3nm chips are being assembled now, right?

Apparently not. Right at the end of August, TSMC announced that it would begin mass producing chips on its latest 3nm node in September. If that initially seems to fit with fall 2022 for 3nm chips, hold on. It takes months of painstaking etching and processing before a bare silicon wafer can be sliced into individual chips.

Most likely, the absolute earliest that actual devices with 3nm TSMC chips could be manufactured would be into December, with retail availability in early next year. And that's if everything from here on goes perfectly.

Meanwhile, TSMC's main rival, Samsung, appears to have stolen a march. In July this year, Samsung announced that it was already mass producing chips on its own 3nm node. Significantly, Samsung has opted for cutting-edge, gate-all-around technology for its 3nm node.

Already, the impact of this mooted TSMC 3nm delay is becoming visible. Apple's recent M2 chip in the revised MacBook Air retained 5nm technology and has proven distinctly power-hungry by Apple's standards.

As we went to press, Apple's new iPhone 14 Pro had just been announced, with its new A16 Bionic chip using TSMC 4nm technology. The standard iPhone 14, meanwhile, uses the A15 5nm chip previously found in the iPhone 13 Pro. Given the recent TSMC announcement regarding its 3nm mass production only being set to begin, it's a clear target missed by TSMC.

Of course, 3nm may only turn out to be a few months behind schedule. We're a long way from the multi-year delays that beset Intel's infamous 10nm node, now rebranded Intel 7. However, from a company that has executed with such millimetric precision over the past decade, even a short delay to 3nm would be conspicuous. It would also offer a much-needed sense of optimism to TSMC's competition.

INTEL 2.0

Intel's woes with its 10nm process node have already been well documented. The company's response is known as 'IDM 2.0', a triple-pronged strategy to return Intel to market leadership. Part one is a commitment to fix its fabs and push on to 7nm technology and beyond.

Part two involves using third-party fabs to fill in the gaps in the meantime, given that it will take several years to fix those Intel fabs. And part three? To become a major player itself in the foundry business making chips for customers.

If part one seems like an obvious, if difficult and expensive to execute step, two and three are intriguing, even contradictory. As it turns out, Intel is turning to TSMC for that interim measure of farming out some of its chips to a third party for production. But TSMC will also, of course, be Intel's primary competition as it scales up part three of the plan and attempts to win foundry customers. That Intel-TSMC relationship sure is going to be interesting.

Indeed, early reports suggest it is already strained. Intel has revealed that TSMC will make the integrated GPU chiplet or tile, known as a tGPU, for its Meteor Lake series of processors. Meteor Lake is the architecture that will follow Raptor Lake, the latter being due later this year as a replacement for the incumbent Alder Lake architecture.

Anyway, rumors currently abound regarding delays in Intel's launch plans for Meteor Lake, pushing planned production from late 2022 to early 2023 and then even later into 2023, and in turn the impact all that will have on TSMC. Analysts at Trendforce even reported that Intel's delays had forced TSMC to scale back on its plans for 3nm production rollout in 2023.

Intel has since revealed that Meteor Lake's tGPU will actually be built on TSMC 5nm tech and insists that the CPU family is not delayed but, equally, Intel will not publicly commit to an actual firm launch date. So, the real situation is not at all clear.

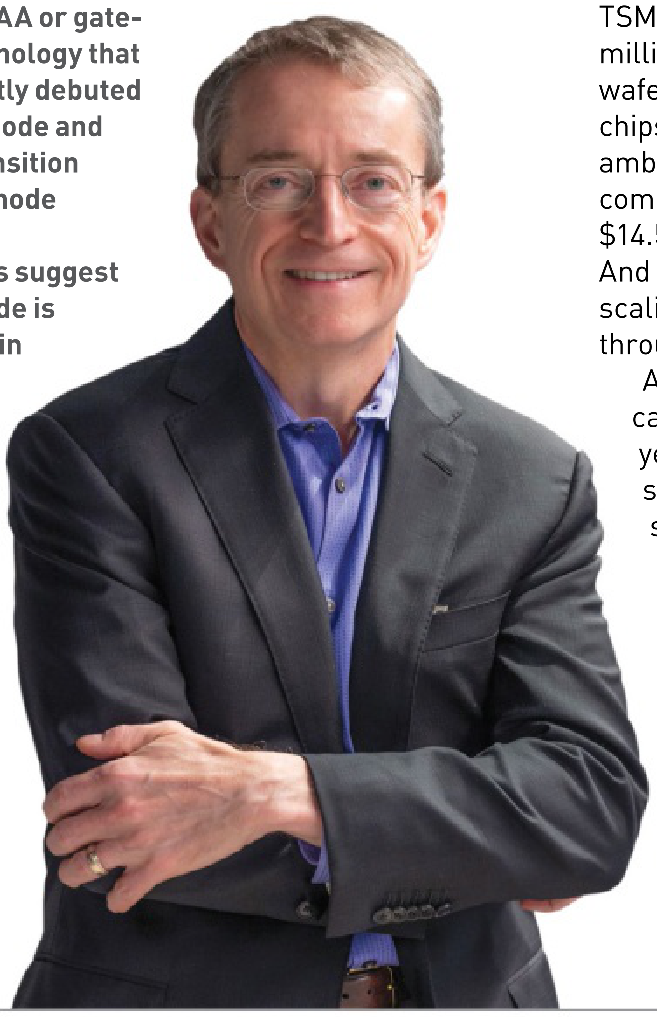
If that part of the IDM 2.0 plan has got off to a shaky start, what about Intel's nascent foundry business? Intel has announced Qualcomm and Amazon Web Services as early customers.

Qualcomm will be using Intel's upcoming 20A process node, which will use Intel's new RibbonFET transistors, the first major revision to Intel's basic transistor design since 2011. RibbonFET is Intel's version of the GAA or gate-all-around technology that Samsung recently debuted in its new 3nm node and TSMC won't transition to until its 2nm node around 2025.

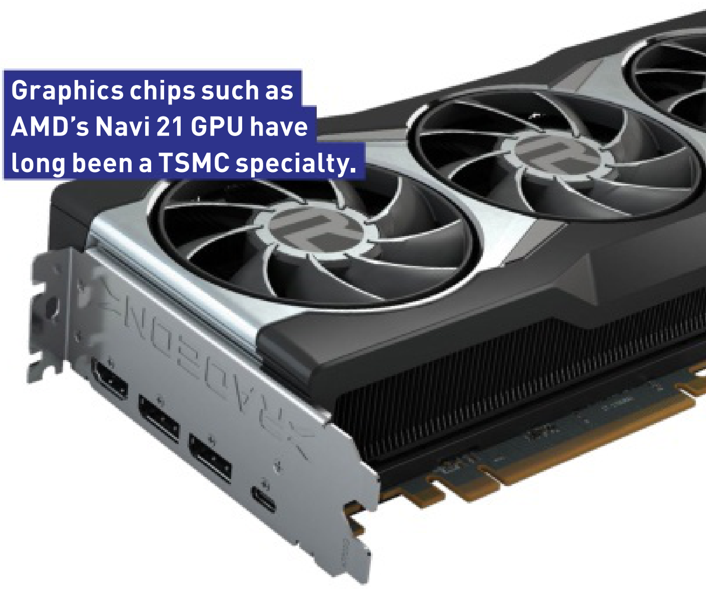
Some reports suggest the Intel 20A node is expected to begin ramping in 2024. But since Intel has yet to ship any commercial products on its 7nm node, marketed as 'Intel 4', that would imply Intel 4 will launch in 2023 and Intel 20A in 2024. While that isn't strictly impossible, it seems incredibly ambitious given the five to six years it took Intel to go from 14nm to 10nm production technology.

Before any of that happens, however, Intel's first major customer will actually be Mediatek. Intel has signed up to produce chips for Mediatek's smart edge devices, including routers, switches, and firewalls. But they won't be on Intel 20A or even Intel 4 or 7. Instead, the chips will be produced on Intel 16, a node we've never heard of before which turns out to be a development of Intel's 22nm technology, which debuted way back in 2011.

All of this makes for intriguing reading, but it doesn't get us any closer to knowing whether Intel can really make a go of its new foundry business.



Intel CEO Pat Gelsinger: The old Intel hand behind its new IDM 2.0 strategy.



Graphics chips such as AMD's Navi 21 GPU have long been a TSMC specialty.

also Dutch electronics giant Philips and several other private investors.

KEY DECISIONS

Early on, Chang made two key strategic decisions that set the template for modern foundries and enabled TSMC's rapid rise. First, he decided to make TSMC a pure customer foundry. It would only make chips for other companies, it would not manufacture its own designs. Second, he priced access to TSMC's fabs well below the competition. The idea was to gain market share and recoup revenues over the full life span of a given process node rather than attempting to make fast money upfront.

Chang was playing the long game. And boy, did it work. By 1992, TSMC was already the world's single largest customer chip foundry. By 1996, the company generated over $40 billion in sales, listed on the New York stock exchange, and also awarded dividend payments of over $100,000 each to its employees. By the following year, TSMC had an overall capacity for one million wafers a year, each fully etched wafer containing hundreds of individual chips. But that wasn't enough for TSMC's ambitions. That year, the company also committed to a 10-year plan to invest $14.5 billion in new production facilities. And that increasing investment and scaling of capacity have continued through to the present day.

As of 2021, TSMC reckoned it had the capacity for 13 million wafer starts per year. Do the rough sums on a typical smartphone chip measuring 100mm squared and produced on TSMC's 300mm-wide wafers, and you can fit over 600 individual chip dies into a single wafer. Subtract a few for inevitable dud dies, call it 500 per wafer once yields have matured and you have the capacity for no fewer than 6.5 billion cutting-edge chips in a single year. Incredible.

Of course, some of the dies TSMC makes for customers are

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MADE IN TAIWAN

Fab 16 is just one of numerous multi-billion dollar production facilities TSMC has in Taiwan.

much bigger than a smartphone SoC. Navi21, the GPU found in AMD's top-spec Radeon RX 6900 series graphics cards and currently produced on TSMC's 7nm node, measures 520mm squared. But whichever way those wafers are actually sliced in practice, you're looking at billions of chips.

As for production facilities, the current list of TSMC infrastructure makes for staggering reading. The company runs four so-called 'gigafabs' in Taiwan using those premium 300mm wafers, within a further 300mm facility in mainland China. It has a further four 200mm fabs in Taiwan and two more 200mm factories, one in China, the other located in Camas, Washington. As if all that isn't enough, a further 300mm fab is currently being constructed in Taiwan, with yet another underway in Arizona.

If that's an overview of how TSMC's raw capacity has grown, the missing piece of the puzzle is how it managed to not just catch up to Intel in terms of both transistor density and performance, but actually overtake it by some measures. If you compare the two company's timelines starting around 20 years ago, the two had similar levels of chip production prowess in the early days. In 1999, for instance, both Intel and TSMC made chips on their respective 180nm nodes.

LEADING BY THE NODE

By 2001, both outfits had upgraded to 130nm technology. However, Intel beat TSMC to both 90nm and 65nm processes by a year in 2003 and 2005 respectively and by 2011 was several nodes ahead, producing 22nm chips. TSMC only moved to its own 20nm process in 2014. What's more, Intel's nodes tend to be one generation ahead in terms of density at any given measure (see boxout opposite). So, it wasn't until TSMC launched its 16nm node in 2015 that it truly had technology on a par with Intel 22nm.

Two things then conspired to completely upend Intel's technological leadership and elevate TSMC to the position of the world's most technologically advanced chip maker. The first was Intel's chronic failure to bring its 10nm node to market. Five long years spanned the gap between Intel's 14nm and 10nm chips, and that's by the most generous measure that counts a tiny number of dual-core laptop chips in 2019 as the first 10nm commercial products. It was actually at least six years between the two nodes if the measure is multi-core chips produced on a truly mass scale.

The other major event was TSMC's coup in winning production of SoCs for Apple's iPhone away from Samsung in 2014. The Apple A8 chip, as found in the iPhone 6, was produced on TSMC's then-new 20nm node. In 2015, TSMC shared production of the Apple A9 chip with Samsung. But ever since, TSMC has dominated iPhone SoC production as the exclusive manufacturer for Apple. The significance of that cannot be understated.

For starters, it has guaranteed huge volumes for TSMC's latest process nodes. Every year, almost without fail, Apple has taken over 200 million SoCs for iPhones alone. That's not counting chips for iPads and now also for MacBooks and iMacs with the new M1 and M2 chips, also produced by TSMC. That has allowed TSMC to aggressively target new nodes with the guaranteed knowledge that it has a customer ready to pay for hundreds of millions of chips.

Just as important, Apple is arguably the most exacting customer in the industry. It has pressured and pushed TSMC all the way, demanding the very best and being willing to pay for it.

TSMC manufactures Apple's world-beating M1 processors on its cutting-edge 5nm node.

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We will never know for sure, but it's likely that the combination of rock-solid financial footing plus external pressure was what motivated TSMC to make at least one critical technical move. In 2019, it began using EUV or extreme ultraviolet lithography for the first time in its 7FF+ node, which was a revision of its 7nm technology of the previous year.

EUV, of course, is widely regarded as critical in moving below 10nm. Notably, Intel has yet to use EUV technology for any of its commercially available nodes, despite its 10nm process being at least as dense as TSMC 7nm. Many industry observers suspect Intel's failure to adopt EUV technology is a major factor in its recent difficulties in bringing the 10nm node up to speed. Whatever, TSMC's early use of EUV on 7nm certainly translated into a swift and successful jump to 5nm the following year, leaving Intel further behind and elevating TSMC to a position of undeniable technical leadership. Without doubt, TSMC now produced the world's most advanced integrated circuits.

The future for TSMC looks almost as bright as it has for the last few years. It has become so costly to compete in the cutting-edge foundry market, arguably only Samsung, Intel, and possibly IBM, can challenge TSMC's dominance. Admittedly there are some signs that TSMC's upcoming 3nm technology is proving a little problematic. However, it will take a monumental mess to allow either Intel or Samsung to catch up, let alone overtake TSMC before the end of the decade. TSMC's advantage is that big.

Ultimately, TSMC's biggest threat isn't other chip makers, it's the potential for political or even military turmoil across the Taiwan Strait, the thin slice of water that separates Taiwan from mainland China. And if something goes wrong in that regard, it won't just be TSMC in trouble. It will be every single person living in the developed world, and indeed beyond, that feels the pain. TSMC is that important. That is both a quite remarkable, but also an acutely worrying, fact.

WHEN TWO TRIBES GO TO WAR

Just 80 miles separates Taiwan from the Chinese mainland.

© TANAONTE/GETTY IMAGES

It's all too easy to flippantly characterize the contest between the big players in chip design and production in militaristic terms. But is TSMC now so important that it could spark not just financial fisticuffs between corporate entities, but a real-world hot war between the USA and China? That is a sobering thought and one that has become rather more ominous in the wake of Russia's recent incursion into Ukraine. After all, there are many parallels between Russia and Ukraine's relationship and that of China and Taiwan.

At their closest point, just 80 miles of water separates Taiwan from the mainland. China, of course, has long maintained that Taiwan remains part of its territory under the One China doctrine. For its part, the US has operated a policy of strategic ambiguity regarding Taiwan. On the one hand, the US does not formally challenge the One China doctrine. On the other, it maintains informal relations with Taiwan including extensive trade and commercial arrangements.

There's no denying how much is at stake. For the US, allowing China to seize control of Taiwan and, in turn, TSMC would mean a huge technological and strategic loss. However, should China take the bold military step of invading Taiwan, it's far from guaranteed that TSMC's foundries would survive intact and fully operational. Far from needing to be bombed to take them out of operation, fabs are hyper-sensitive to supply chain interruptions or any kind of contamination, never mind the loss of critical staff.

And even if China somehow managed to take control of the island while maintaining a short-term operation of TSMC's fabs, the medium to long-term outlook would likely be grim. To take one example, TSMC along with all other current cutting-edge fabs, relies on EUV lithography machines produced by the Dutch company ASML. One fairly obvious western response to any Chinese aggression in Taiwan would be to cut off the supply of further ASML machines, which would almost certainly set TSMC back a decade or more.

In many ways, Taiwan and TSMC looks like an intractable problem for both China and the US. Any attempt to forcibly seize Taiwan would almost automatically undermine its economic value to China. But equally, there is arguably little that the US could do to stop China short of all-out war. And in that scenario, TSMC would be the least of everyone's worries.

With all that in mind, it's not terribly surprising to find that both the US and China are taking major steps to improve their domestic chip production capabilities and essentially sidestep the TSMC problem altogether. The US has the Creating Helpful Incentives to Produce Semiconductors for America Act or CHIPS Act, legislation that was recently signed into law with unusually bipartisan support and sets aside $52 billion to boost domestic semiconductor research and production.

Meanwhile, a recent Biden administration review of supply-chain vulnerability concluded that China is pumping something in the order of $100 billion into subsidies for its own chip industry. All of which means that the worst-case scenario of a hot war looks unlikely. But economic conflict is pretty much a nailed-on certainty.

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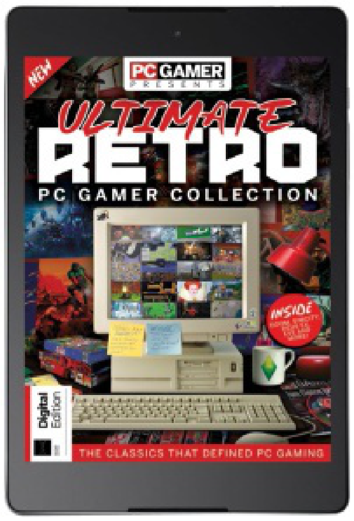
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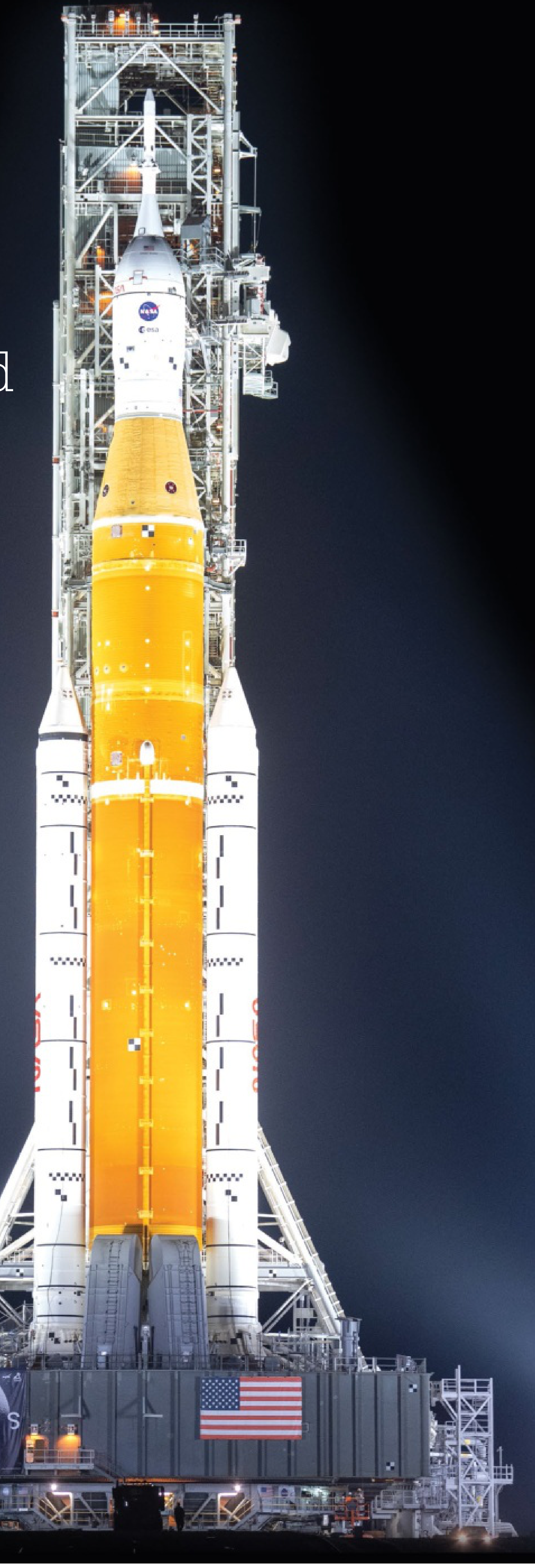
LINUX IN SPACE!

With the OS now established in astronautics, *Mike Bedford* looks at its future prospects



WHY DO ASTRONAUTS use Linux? Because you can't open Windows in space. Joking aside, the truth is that the heavens aren't full of Linux computers—but all that could be about to change.

Over the next few pages, we'll look at how Linux is becoming an important facilitator in space exploration. And that takes us from NASA's supercomputers here on Earth through to laptops in orbit on the International Space Station (ISS) and flight control computers on SpaceX's launch vehicles and spacecraft, to a single board computer empowering a helicopter flying on Mars.

As well as looking at where and how Linux is used in astronautics, we'll also delve into why it's used. The migration of Linux into space is a recent phenomenon, though, and it's still far from universal. So, we'll also investigate what has previously held Linux back in space and, to a significant degree, continues to do so today. We'll also examine what the prospects are for it to boldly go where no operating system has gone before.

OPERATING BEYOND THE EARTH

We're going to be looking at where Linux is being used in space exploration. But first, we need to consider space-based computing platforms and, in general terms, how they have influenced the operating system of choice.

Take the ISS, for example, which was launched over 20 years ago. With Linux being the new kid on the block back then, it wouldn't have been given serious consideration and upgrading now would barely be feasible. Much of the in-built computer hardware wouldn't support modern distros and upgrading the hardware and software would be a costly and high-risk strategy.

But even some much more recent space missions have failed to embrace Linux. The Perseverance Martian rover touched down on Mars in February 2021 and will continue to explore the red planet for quite some time yet. But its main onboard computer uses a PowerPC 750 processor—a chip that launched back in 1997. To be more accurate, it uses a variant of the 32-bit PowerPC 750 called the RAD750, and this brings us to a key point. Processors don't fare too well in space. Because of the radiation they constantly have to endure, they are much more likely to suffer occasional glitches, or even catastrophic and permanent failures, than their Earth-bound cousins.

NASA's Artemis program doesn't have onboard Linux machines. But on Earth, Linux is critical to pre-launch simulations.

For this reason, processors used in space are usually radiation-hardened to withstand the rigors of life beyond Earth's atmosphere. These specialist processors aren't cheap. RAD750s cost around US$200,000 each, so we can't imagine how much they cost to develop.

The bottom line is that manufacturers bring out new radiation-hardened chips infrequently, and most chips never spawn a radiation-hardened variant. This is a further reason for the antiquity of computing hardware in space, and hence the scarcity of Linux in the heavens. But things are changing here, including on the Spaceborne supercomputer on the ISS.

It only touched down in 2021, but the Perseverance Martian rover's main processor is based on the venerable PowerPC 750 processor. So, little wonder it doesn't run Linux.

IN EARTH ORBIT

Although widely-reported stories suggest that all the laptops on the ISS migrated to Linux back in 2013, the reality is more nuanced, according to Dan Duncavage, system manager of NASA's ISS Avionics and Software Office. "As you can imagine, the station contains many computational devices," he says. "Most of them are highly custom and function like avionics systems that you might find on an airliner or military aircraft." Although he didn't specifically admit it, these mission-critical systems don't employ Linux. However, beyond these central systems, we find a more varied situation.

"There's a subset of laptops and small computer boxes where Linux is used," he says. "A handful of the laptops are used by the crew as their command interface to the core avionics systems. These are based on a customized Linux kernel. The avionics interface and crew user interface software are all purpose-built for these functions, and reside on top of that Linux kernel," Duncavage explains.

"Additional laptops and IoT devices make up what's called the Station Support Computer (SSC) System. This is similar to what businesses would call a mission-critical IT infrastructure. It supports everything from email to highly custom experiment interfaces and all of the crew's medical monitoring—and it runs the unique space exercise equipment," says Duncavage. "The majority of the SSC laptops are Windows 10 clients; the IoT devices are built on Debian Linux. The remaining laptops are distributed to experiment-specific applications and international partners. Some of these are Windows and some are Linux of various distributions," he says.

Onboard the ISS are Honey, Queen, and Bumble. Collectively, these free-flying robots form the Astrobee system. Their job is to help astronauts reduce the time they spend on routine duties, leaving them to focus more on the things that only humans can do. According to NASA, the robots are designed to complete tasks such as taking inventory, documenting experiments conducted by astronauts with their built-in cameras, or working together to move cargo throughout the station. In addition, the system serves as a research platform that can be outfitted and programmed to carry out experiments in microgravity—helping NASA learn more about how robotics can benefit astronauts in space. And its control computers run Linux, more specifically two of its three ARM-based computers run Ubuntu/ROS, while the third is equipped with Android 7.1.

So we've seen Linux-based laptops and flying robots in Earth's orbit, but a more powerful Linux machine was taken to the ISS in 2017 for a year-long mission. Called the Spaceborne Computer, it has been described as a supercomputer and its purpose was to research alternatives to the usual radiation-hardening approach for protecting computers from the hazards of radiation exposure. This, it's

GEARING UP THE RASPBERRY Pi FOR SPACE

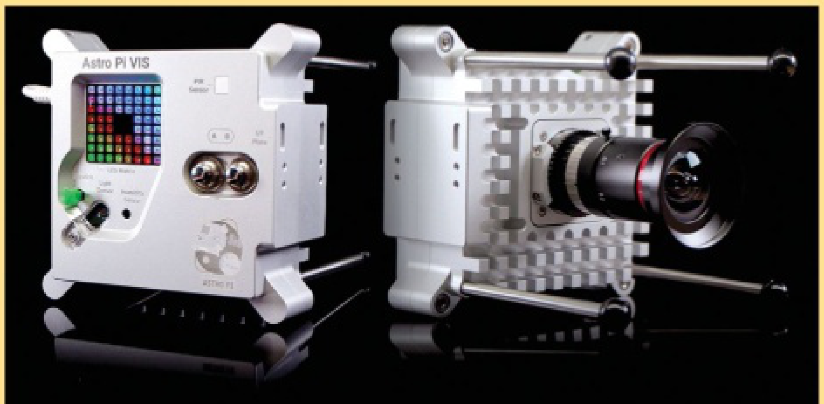
An initiative of the European Space Agency in collaboration with The Raspberry Pi Foundation, Astro Pi is providing teams of young coders with the opportunity to see their applications running aboard the International Space Station, Python, and the Linux Operating system.

The Astro Pi platform comprises an RPi 4, a sensor HAT, and an HQ Camera. But, as you can see from the photograph, it doesn't look like any previous Raspberry Pi-based platform.

Stringent testing was required before the Astro Pi was allowed onboard the ISS. First, the machine had to be capable of withstanding the huge vibrations that occur at lift-off. To ensure the safety of the astronauts who will use them, the surface temperature of the case couldn't exceed 45°C.

It also had to have no sharp edges and it had to be proven that it wouldn't interfere with other equipment on the ISS, or that such equipment would interfere with the Astro Pi.

Two of the latest generation of Astro Pis were taken to the ISS in December 2021, to replace the previous Astro Pis that had spent six years in orbit.



The Astro Pi contains Raspberry Pi hardware, allowing young people to see their code working onboard the ISS.

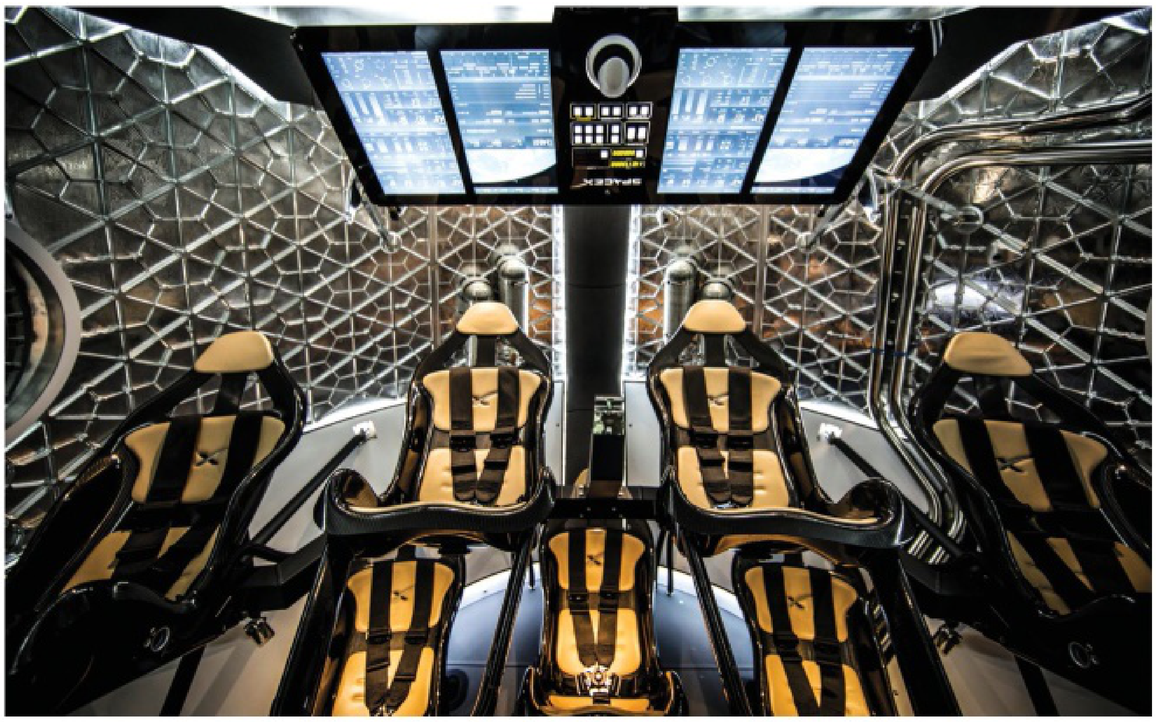
Following a test period by astronauts in space, they are now ready to run student programs. Entries were open to teams of young people, aged 19 or under, from ESA member states, plus Slovenia, Canada, Lithuania, Latvia, and Malta. Winning entries were deployed in May, with the 2022-23 challenges launched in September.

© NASA, ESA/NASA, NASA/JPL

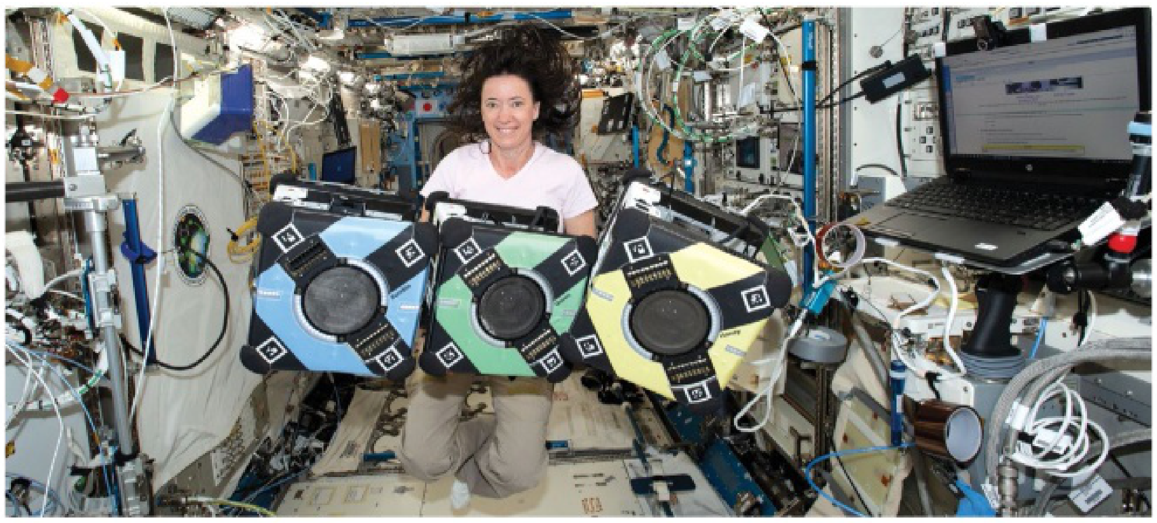
suggested, will pave the way to using more up-to-date and higher performance processors than are currently used, as would be required for future long-term manned missions, such as to Mars.

The Spaceborne Computer is a commercially available supercomputer, designed and produced by Hewlett Packard Enterprise (HPE). It includes HPE Apollo 40-class systems with a high-speed interconnect, running an open-source Linux operating system. According to HPE, the Spaceborne Computer contains compute nodes of the same class as Pleiades, one of NASA's premier supercomputers.

As an alternative to using radiation-hardened processors, a software solution was developed to mitigate the negative impacts of radiation on reliability. During high-radiation events, the electrical power consumption and, therefore, the operating speed of the computer system was lowered, with the aim of determining if such systems can still operate. The conclusion was favorable. During its demonstration mission, the Spaceborne Computer performed more than one trillion calculations per second (one teraflop) for 207 days without requiring a reset.


SpaceX's flight control computers aboard craft such as this Crew Dragon operate under Linux, in a marked departure from NASA's usual approach.

While we've not yet seen Linux employed in NASA's mission-critical jobs, that situation is changing and the ISS is a beneficiary. Until it was retired in 2011, the Space Shuttle took astronauts and supplies to the ISS, alongside the Russian Soyuz and a few other launch vehicles. For a while, the USA had to hitch a ride to the ISS on the Russian launch vehicle, but then, in 2012, the forces of capitalism came into play. Space was no longer the sole domain of government-owned space agencies. Now, the ISS is also supplied by launches by SpaceX and Northrop Grumman Space Systems. And the SpaceX Dragon spacecraft and its Falcon launch vehicle are especially interesting.


These floating Astrobee System robots run Linux and assist the ISS crew with basic tasks.

Where NASA leads, SpaceX follows, you might think. But that isn't the case with its choice of operating systems. For while NASA's forthcoming SLS launch vehicle uses a proprietary Boeing operating system in its flight control computer, and the Orion crew exploration vehicle uses a real-time operating system called Integrity-178B from Green Hills Software, it appears that SpaceX is firmly in the Linux camp. But this is no ordinary Linux, and certainly not any distro you might choose for your PC.

Although SpaceX hasn't confirmed it, the consensus is that the Falcon 9 launch

SUPERCOMPUTING AND SPACE EXPLORATION

NASA is intent on returning astronauts to the Moon for the first time since Apollo 17 in 1972. Called the Artemis program, it is based on the Orion spacecraft that will be launched on the new Space Launch System (SLS) rocket.

Given NASA's apparent reluctance to use Linux for mission-critical applications, it probably comes as no surprise that Linux doesn't form a part of either Orion or SLS. That doesn't mean that the success of Artemis won't depend on Linux though.

Underpinning the design and verification of all NASA's spacecraft is simulation, and Artemis is no exception. It's not surprising that these simulations are hugely processor-intensive, so some serious computing muscle was called for.

Simulations of the landing process, for example, are being carried out at NASA's AMES Research Center in California on a supercomputer called Aitken. In November 2021, when it boasted 242,688 cores, it was the world's 49th fastest computer, but it's been expanded since. Needless to say, the operating system has powered all the world's 500 fastest supercomputers since 2017.

If you want to know why Linux is the undisputed king of supercomputing, with commercial top-end operating systems being licensed per core, if you've got a quarter of a million cores, FOSS is surely the way to go. Such financial considerations are just the tip of the iceberg.

© NASA, NASA/SHANE KIMBROUGH,

vehicle uses a stripped-down version of Linux running on x86 processors, and the flight control software was written in C++.

FURTHER AFIELD

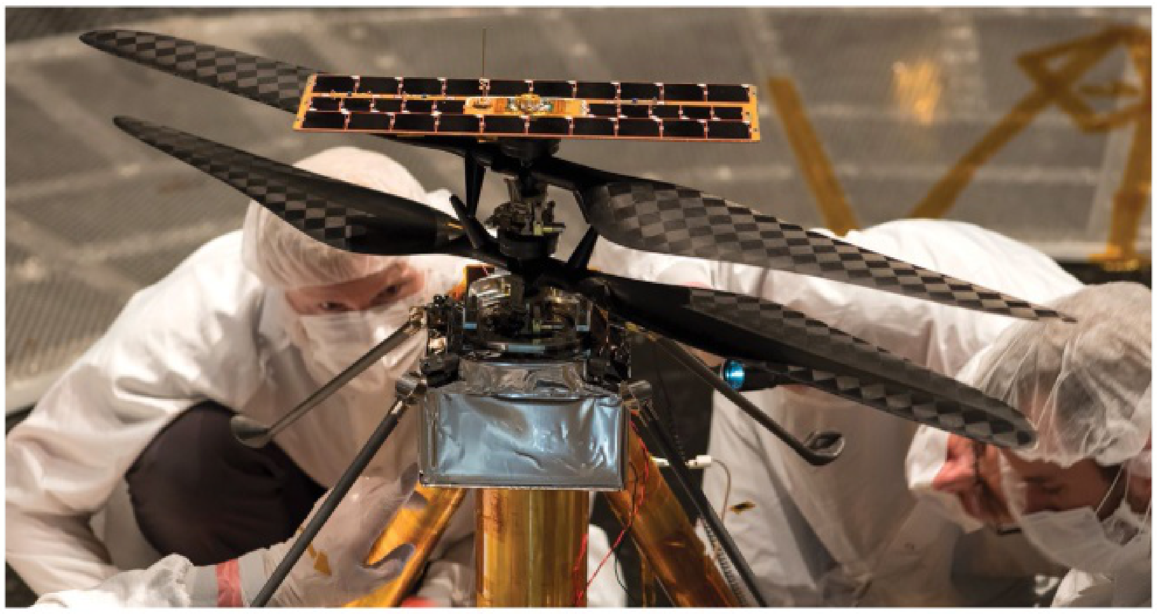
We'd love to be able to tell you that a Linux-based computer is on board the Pioneer 10 and 11 spacecraft, which have now left the Solar System, heading for the stars. But the first of these probes was launched just four months after the first microprocessor, Intel's 4-bit 4004, landed on the market. The Pioneers carried computers made from individual logic chips that probably didn't even have an operating system. However, Linux can be found beyond the confines of the Earth, 173 million miles beyond it, in fact—and it took over six months to get there.

The Jet Propulsion Laboratory in California is responsible for NASA's missions to Mars and beyond. Tim Canham, senior flight software engineer at JPL, explains the factors behind the increased use of Linux in space. First the success stories. "Linux has had two prominent uses here at JPL," he says. "The Mars Ingenuity helicopter and the Perseverance Rover EDL camera system. Both systems were considered technology demonstrations and weren't critical to the survival of the Rover, but Linux has performed well in both cases."

Given that Linux is excluded from some space projects because of the antiquity of the computing hardware, one reason for its inclusion on Ingenuity makes a refreshing change. The Martian atmosphere is more than 100 times thinner than Earth's and this places huge demands on the design of an aircraft intended to fly on the planet. As well as larger-than-usual rotors, keeping the weight down to a minimum was critical, and this brings us to the computing hardware.

An ARM-based Qualcomm Snapdragon 801-based computer system was chosen to meet these strict requirements. Linux was selected because the VxWorks operating system that would normally be used by NASA in such applications wasn't available for the Snapdragon chip.

So why are these applications the exception rather than the rule? Apart from the legacy nature of the computing hardware often used in astronautics, what else has held back the application of Linux? Canham suggests a few reasons, including a concern about real-time performance. "Flight software typically has hard software deadlines that have to be met to guarantee the survival of the spacecraft. If the operating system can't make guarantees that those deadlines can be met, it can't be used.



Seen here undergoing a final inspection prior to launch, the Ingenuity drone is now operating on the red planet, thanks to its Linux-based computer.

© NASA/JPL/CALTECH

"Linux isn't primarily designed as a real-time operating system. It has real-time patches to the mainline kernel to improve the performance, but applying it to modified kernels provided by board vendors has been problematic. The fairness algorithm and underlying I/O make it hard to guarantee the timing."

His second reason might cause a few hackles to be raised. "Fairly or not, there's a perception that since Linux is based on a lot of open-source contributions, it's difficult to know or reasonably assess the quality of the code that comprises the kernel, drivers, or other apps running in the distribution."

But things are changing, as Canham explains. "The role of Linux is evolving and different organizations have different risk postures related to usage, but for NASA, Linux can find a niche in areas where it has advantages: data processing and operation of fight hardware in non-critical contexts. Linux brings huge open-source advantages that can speed development and take advantage of software already available in the community. I also think there's a chance to deploy Linux in a compute environment where hypervisors can separate the real-time domain from the processing domain."

So while Linux hasn't yet turned space exploration on its head, changes are taking place. And you can take some comfort in the fact that Ingenuity, the first aircraft ever to fly above the surface of an alien world, is a Linux-powered miracle of astronautical engineering.

INTRODUCING CUBESATS

Space exploration might have evolved to use commercial service providers such as SpaceX, but further democratization of space research is just a pipe dream, you might think. But you'd be wrong.

CubeSats are tiny satellites, measuring just 100mm across and weighing no more than 1.33kg. They can cost as little as £38,000 to build and because they can be launched from the ISS or as a secondary payload alongside more mainstream satellites, they can be launched for not a lot more. As such, they have formed the basis of student projects, often with funding from bodies like the ESA, and have even been built by groups of enthusiasts, for example, amateur radio societies.

Although Linux isn't universal in CubeSats, given that the open source philosophy is key to much of the CubeSat community, it's no surprise that Linux is a common choice, alongside the likes of FreeRTOS.

The open-source approach goes well beyond the operating system, and it isn't even restricted to the software. Open hardware processor boards are common. You can find designs for components such as thrusters, and there have even been complete open-source satellites, including a design by the Libre Space Foundation.

What's more, there are networks of open source satellite ground stations and, if you have access to a 3D printer you can even build your own ground station for just a few hundred dollars.

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ARE YOU LOOKING to create an exciting and fun space in which to sit back and unwind? A place to watch your favorite films and shows after a hard day's work? Then a cinema room could be the perfect way of doing that. Contrary to popular belief, you don't need the biggest of rooms nor does it need to cost the Earth. Projectors are becoming more affordable, more compact, and more powerful than ever, with a huge range of models to choose from.

Projectors haven't always been the first choice for gamers—one of the drawbacks was their lack of gaming performance. A big input delay and a display that tops out at 60Hz means that while media consumption was great, gaming wasn't a viable option. For this reason, gamers have tended to stick to a more traditional monitor—with small response times, high refresh rates, and a crisp resolution.

However, that could all be about to change with the BenQ X3000i, a projector that aims to bridge the gap between home cinema and gaming on the big screen. Maybe it's the wow factor when you can get a display of up to 300-inches in the comfort of your own home or maybe it's a quality of picture that you've only ever dreamed of at this size. Either way, projectors are now a great alternative, and this BenQ X3000i allows you to experience gaming at its very best. **–SAM LEWIS**

1 EXTERIOR CHECK

Of course, you won't actually be looking at the projector while it's playing, but the design of the X3000i is one to be admired.

Sure, it isn't the smallest projector out there, but its compact cube-like form is small enough to fit in most rooms—a welcome departure from the traditional cumbersome projector.

We love the white, orange, and black color scheme, especially the geometric cube pattern that's featured on the front. The orange accents add a splash of color without making it incompatible with your room's styling.

2 CRYSTAL CLEAR

When it comes to projector quality, the X3000i smashes it out of the park.

With a native resolution of 4K UHD 3840×2160, when connected to a PC and running 4K movies, the image is crisp with deep velvety colors, even at a display size of around 150-inches.

It blows your average TV screen out of the water—you won't want to go back to a smaller display. It uses a 4LED light source, which is incredibly bright, so using the X3000i during the day is possible, although it's always better with the curtains shut.

3 GAMING, TICK

To get the most out of the BenQ X3000i projector, scale it down to 1080p resolution so you get to experience the full 240Hz. There's still an input lag of 4.2ms at these settings, but it doesn't affect the experience—it's still good enough for online sessions of your favorite first-person shooter.

Racing games and open world titles look insane, even at 1080p, and though we wouldn't recommend gaming competitively, when you kick back and hook up a controller to your PC, you can get lost for hours gaming on the big screen.

BEST OF GAMESCOM 2022

The world's biggest video games show is back after three years. *Guy Cocker* was in Germany to see all the latest games and hardware

VIDEO GAME CONVENTIONS have had a strange few years. The Electronic Entertainment Expo in Los Angeles went virtual for a couple of years during the pandemic but was canceled this year, before being handed over to new management for the 2023 show.

Similarly, Gamescom in Cologne, Germany, has had no in-person show for the last couple of years, which was even more disappointing as it's also open to the general public. This year, the convention returned to its in-person form, welcoming 265,000 gaming fans into the halls of the city's convention center to see new games, new hardware, and more than a few cosplayers.

Most of the big publishers were present, including Ubisoft, Sega, and 2K Games, in addition to hardware manufacturers such as Xbox, Razer, and Samsung. We fuelled up on salted pretzels, weaved through the armies of cosplayers, and scoped out the 500 exhibitors to find all the very best games and hardware. There's plenty to look forward to, but here's the creme de la creme of what we saw.

Wreckreation

It's felt like there's been a *Burnout*-shaped hole in the arcade racer market for some time, which is probably why producer Alex Ward, who worked on the original franchise at EA, is ready to return to the genre with *Wreckreation*. To be fair, he kind of already did with 2019's *Dangerous Driving*, and this is essentially the sequel, although with a much bigger online focus and the resulting shift to building and remixing tracks. Thankfully, the over-the-top crashes that made *Burnout* so much fun are also present and correct.

• Out: 2023 • www.wreckreation.thqnordic.com

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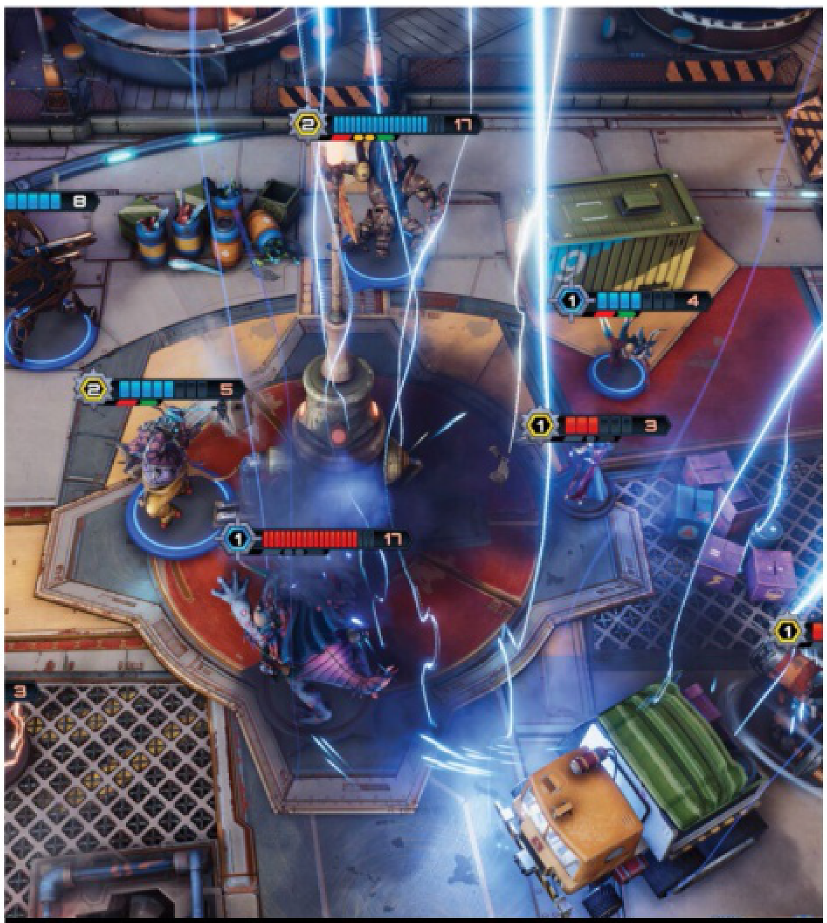

Moonbreaker

All you really need to know about *Moonbreaker* is that it's from Unknown Worlds Entertainment, the creators of the brilliant *Subnautica*. However, don't expect anything similar to that underwater adventure game as this is a complete departure. It's a tabletop-style miniature-focused turn-based sci-fi game similar to something like *Warhammer 40,000*. In the video game world, the closest comparison is probably *Hearthstone*, by the developer's own admission, with strategy and unit selection being key. The game is available in Early Access now.

- Out: September 2022 (Early Access)
- www.unknownworlds.com

Gotham Knights

Another games show, another *Gotham Knights* demo, but at least this game will finally be arriving by the time you read this, on October 21st. Developer WB Montreal showed off 10 minutes of new gameplay at Gamescom, with the open world accessible pretty much from the off, with each of Gotham's five districts having its own characters and villains to deal with. There may be no Batman in *Gotham Knights*, but Nightwing, Robin, Red Hood, and Batgirl should ensure plenty of variety.

• Out: 21st October 2022 • www.gothamknightsgame.com

Return To Monkey Island

Out now by the time you read this, *Return to Monkey Island* made a triumphant showing at Gamescom for fans who never gave up hope of series creator Ron Gilbert returning to continue the tales of star Guybrush Threepwood. Gilbert has partnered with many of his original team, including writer Dave Grossman and Threepwood actor Dominic Armato, to create a traditional point-and-click adventure game, albeit one that's more accessible for newcomers, including a new inventory system, reactive dialogue, and a more modern look.

• Out: September 2022 • www.returntomonkeyisland.com

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Samsung 990 Pro

We were hoping for Samsung to release a Gen 5 SSD soon, but alas that wasn't to be at Gamescom. Instead, the company released an iterative update on the already excellent 980 Pro, featuring its latest V-NAND and a new proprietary controller. This allows the drive to be up to 50 percent more power efficient when compared to its predecessor, while Samsung also claims up to 7,450MB/s and 6,900 MB/s sequential read and write speeds, which is another big boost. A 4TB model will follow after the 1TB and 2TB launches this October.

- Out: October 2022 • www.samsung.com
- Price: $179 (1TB), $309 (2TB)

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Sony DualSense Edge

Microsoft has long had a premium controller with its Elite series, and Sony has finally made something similar with its DualSense Edge. The pad boasts different stick caps such as standard, high dome, and low dome, as well as swappable back buttons (half-dome and lever types) which can be remapped as other buttons. Customization is the name of the game—you can control the travel distance on each trigger, adjust voice chat levels, and save settings as profiles to be accessed mid-game. Let's hope it works on PC with ports such as *God of War* and *Marvel's Spider-Man Remastered.*

• Out: TBC • www.playstation.com

Lies of P

Lies of P is the Bloodborne-meets-Pinocchio game no one knew they wanted, but which stole the show with its enticing trailer on the opening night of Gamescom. There's no doubting that this is heavily influenced by FromSoftware's games, but those wanting a fix after *Elden Ring* will welcome that. Our hands-on was highly encouraging, with gorgeous visuals, engaging combat, and that all-important difficulty level all demonstrating that the developer understands the genre.

• Out: TBA

• www.neowizglobal.com

The Last Case of Benedict Fox

If you're a fan of beautifully drawn 2D platform games such as *Ori and the Will of the Wisps,* then this definitely needs to be on your radar. Although there's a lot of the same platforming, action, and puzzle solving present in that game here, there's more to it thanks to its Lovecraftian setting and emphasis on solving murders. As Benedict Fox, you're able to delve into the minds of the recently deceased to investigate murders in a game set to a rare jazz score and featuring plenty of Tim Burton-inspired visuals.

• Out: Spring 2023 • www.xbox.com

The Callisto Protocol

We have to admit, we were slightly concerned about *The Callisto Protocol* from our Gamescom experience. The game is out in a couple of short months, but there was no playable demo at the show, just a lame augmented reality demo which punters had to queue 30 minutes to experience. But that said, this survival horror game is from the creative minds behind the *Dead Space* series and looks absolutely stunning (read: terrifying) in trailers, so we're keeping an open mind for now.

• Out: 2nd December 2022 • callisto.sds.com

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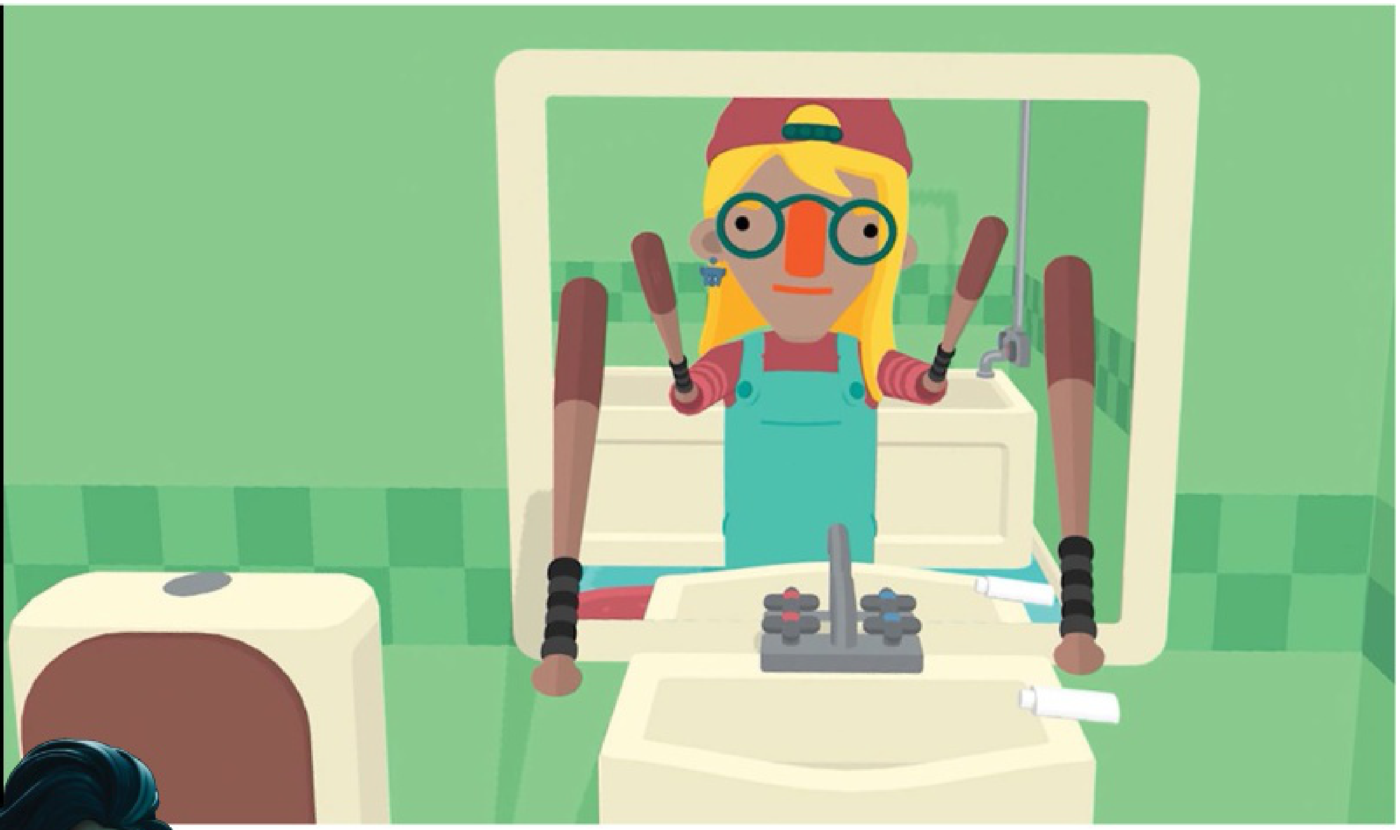
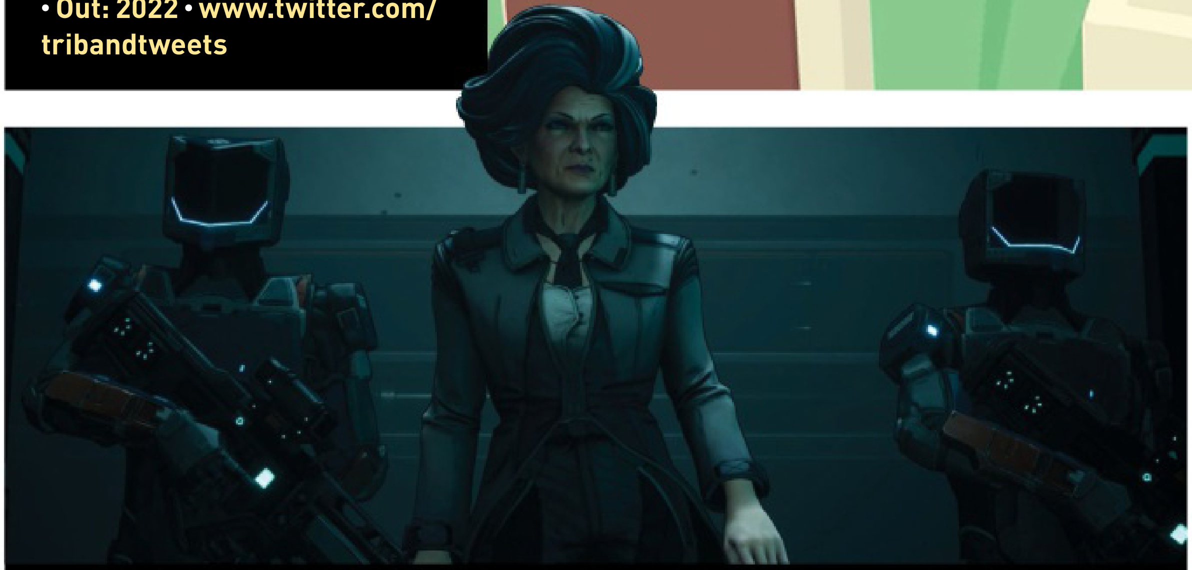
What the Bat?

What the Golf? gets the follow-up it deserves in the form of a VR-based baseball gauntlet runner. The predecessor's absurd sense of humor has thankfully made it intact, as you'll be using baseball bats to perform insane challenges such as carrying an egg, playing a soccer goalie using bats to save goals, or playing a sculptor using a baseball bat to carve a statue. We're sure there will be more weirdly funny problems to solve in the finished game, which should be out before the end of the year.
• Out: 2022 • www.twitter.com/tribandtweets



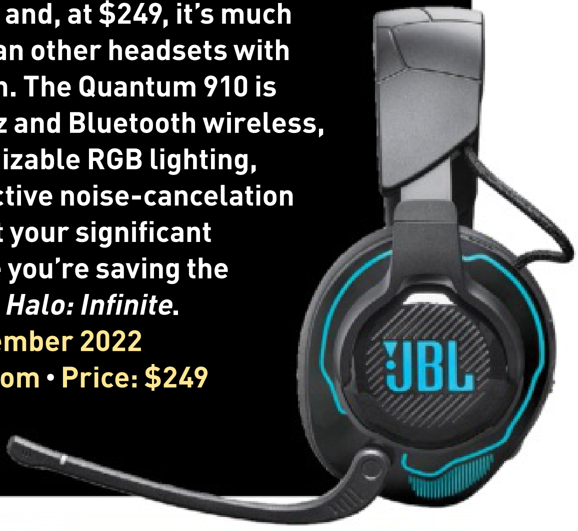


New Tales from the Borderlands

Another game set for release around the time you read this is *New Tales from the Borderlands*, a new entry in the seemingly never-ending *Borderlands* series. The original was developed by adventure game specialists Telltale, but as they're now defunct, this follow-up is being developed by Gearbox. You can expect the usual *Borderlands* art style and humor, but new systems such as an adjustable quick time event (QTE) difficulty that won't impact upon the story experience.
• Out: 21st October 2022 • newtalesborderlands.2k.com

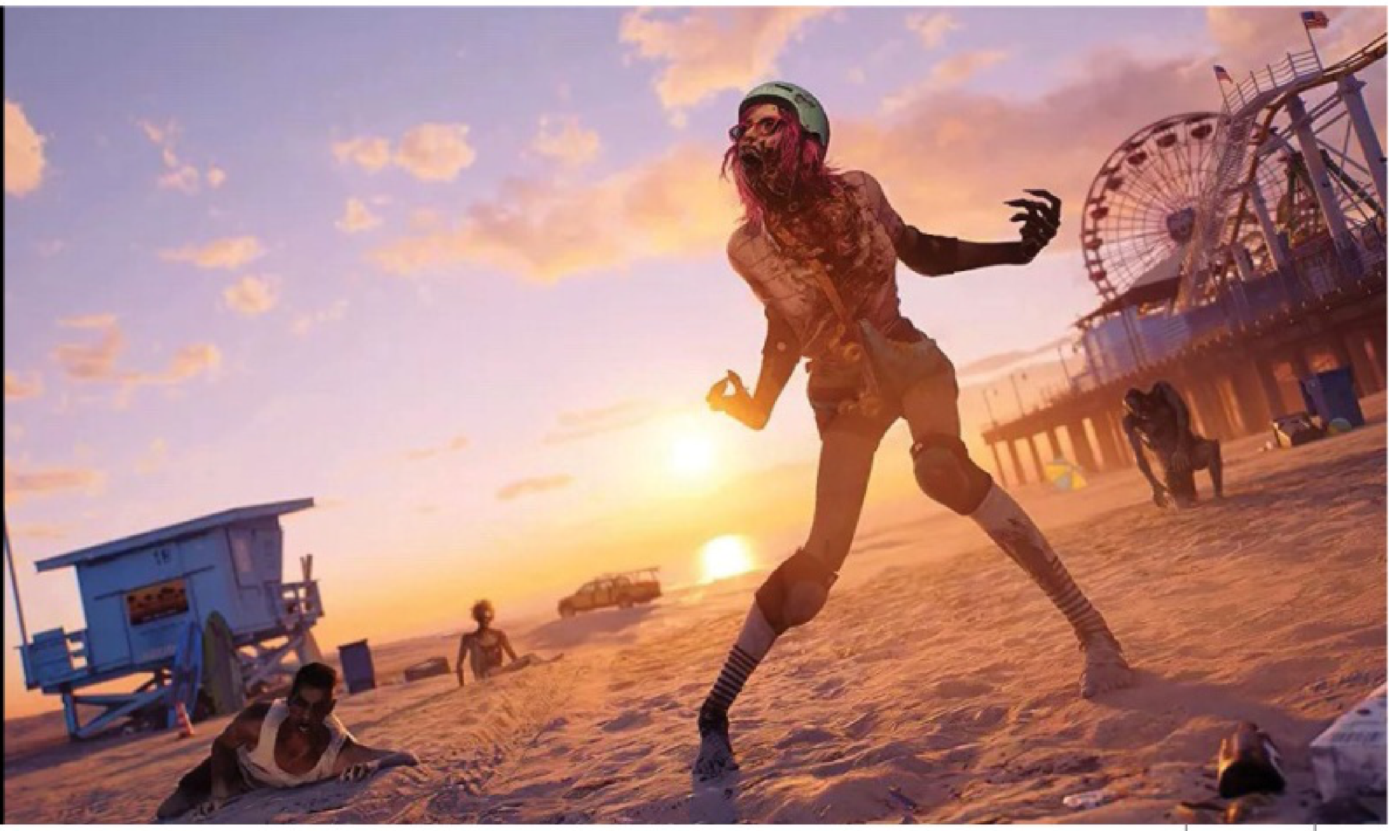
JBL Quantum 910

Further extending JBL's push into the gaming space, the Quantum 910 is notable for its spatial 360° audio credentials that use head-tracking sensors to deliver immersive audio. The result, at least from our short demo at Gamescom, is highly impressive and, at $249, it's much cheaper than other headsets with similar tech. The Quantum 910 is also 2.4GHz and Bluetooth wireless, has customizable RGB lighting, and even active noise-cancelation to block out your significant other while you're saving the universe in *Halo: Infinite*.
• Out: September 2022
• www.jbl.com • Price: $249

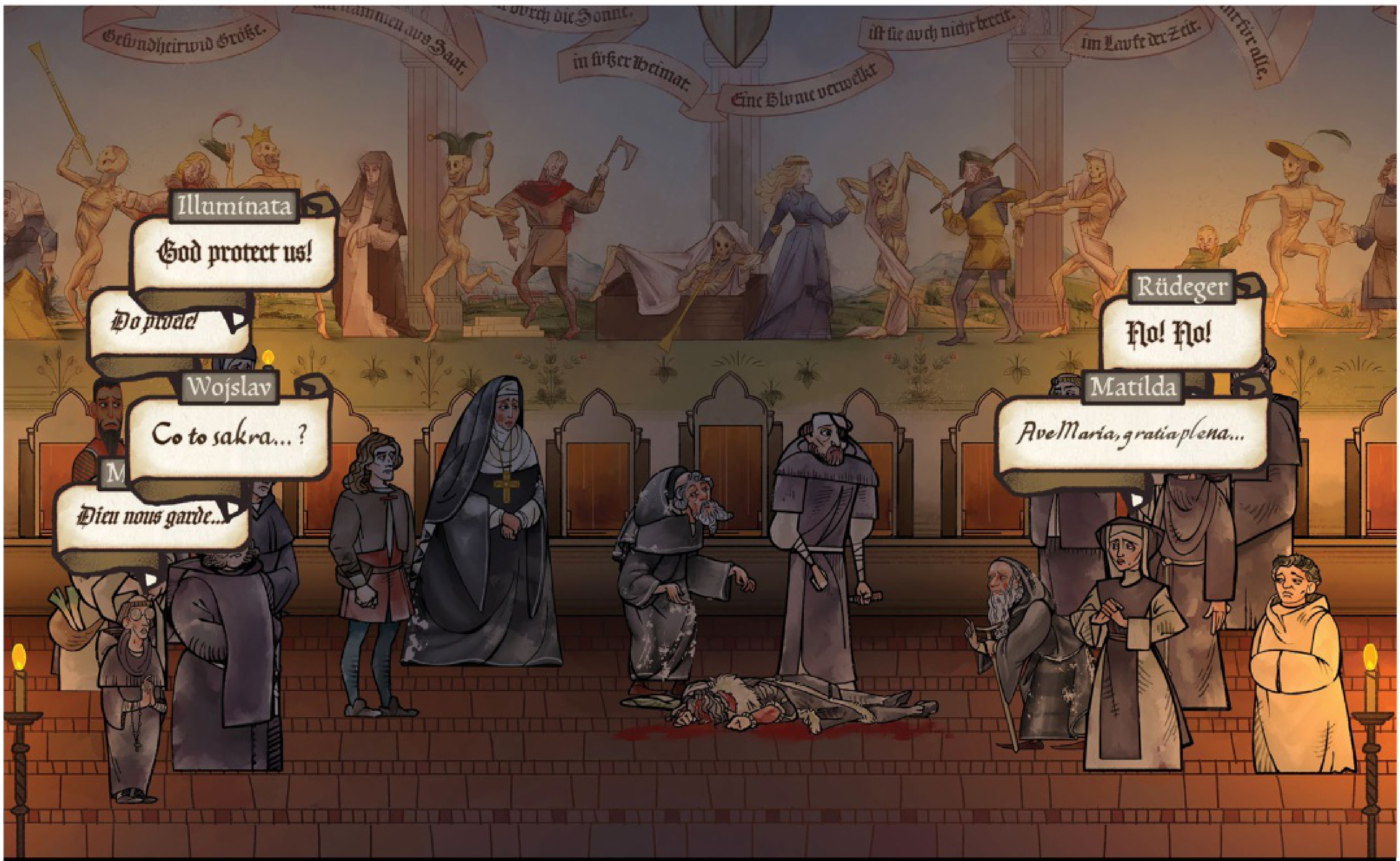


Dead Island 2

Originally announced in 2014, *Dead Island 2* has spent the last eight years in development hell. Originally under the direction of Yager Development, the game then shifted to Sumo Digital, which was later replaced by Dambuster Studios. The latter appears to have finally been able to corral the game into releasable shape. Our hands-on demo was encouraging, full of inventively grisly weapons, imaginative zombie types, and a decent sense of humor. We'll hopefully see it early next year.
• Out: Early 2023
• www.deadisland.com

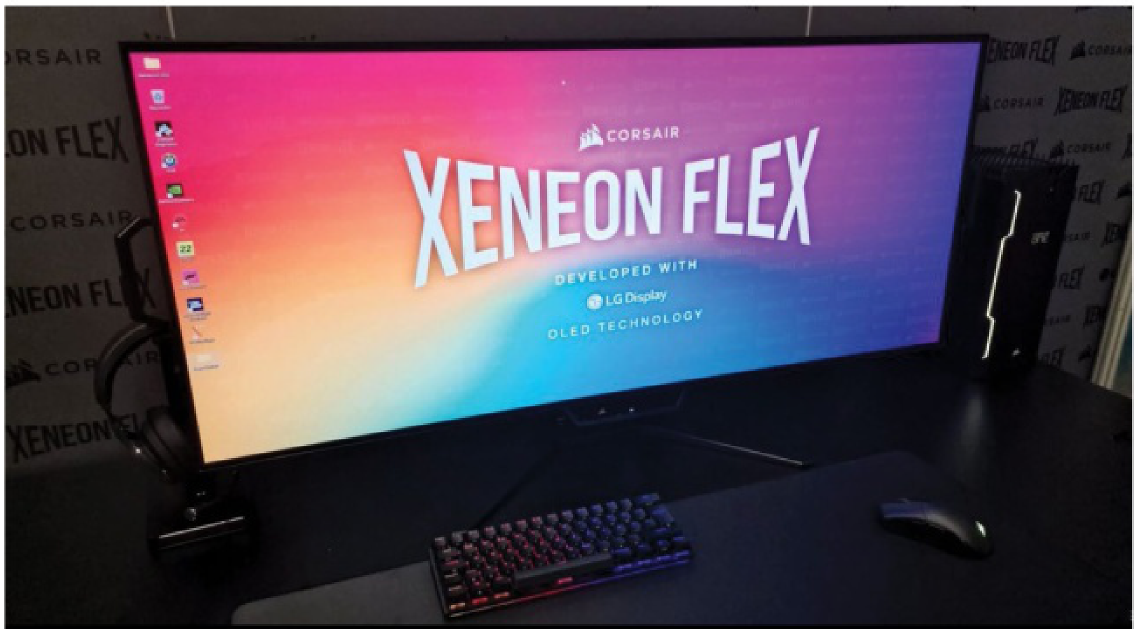


© DEEP SILVER/PLAION, 2K GAMES, TRIBAND, JBL


Geſundheit und Größe.
in ſüßer Heimat.
Eine Blume verwelkt
iſt ſie auch nicht bereit.
im Laufe der Zeit.
Illuminata
God protect us!
Do prdele!
Wojslav
Co to sakra...?
M
Dieu nous garde...
Rüdeger
No! No!
Matilda
Ave Maria, gratia plena...

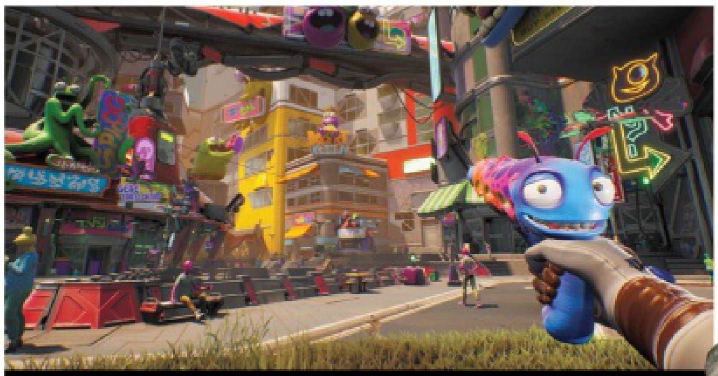
Pentiment

Pentiment couldn't come from a higher pedigree, given it's being developed by legendary RPG specialist Obsidian Entertainment. But stylistically at least, it's a huge departure for the studio given its 2D medieval art style. The game itself is about solving murder mysteries (a common theme for Gamescom this year, see also: *The Case of the Golden Idol*) in 16th Century Bavaria. The game has a wicked sense of humor, thanks to the Obsidian trademark dialog choices, and is due to land on Xbox Game Pass soon.
• Out: 15th November 2022 • www.xbox.com


CORSAIR
XENEON FLEX
DEVELOPED WITH
LG Display
OLED TECHNOLOGY

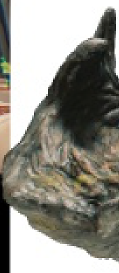
Corsair Xeneon Flex

Ever wanted a monitor that's both a flat AND curved screen? No, us neither, but that hasn't stopped Corsair from partnering with LG's OLED division to make it happen. Corsair is pitching it as the perfect monitor for accuracy when playing first-person shooters, while immersiveness in *Forza Horizon 5* can be improved by making it curved. Two handles on either side allow you to bend the monitor into an 1800R curve, while gaming credentials are boosted with 240Hz refresh, 3440 x 1440 ultrawide resolution, and a 0.1ms response time.
• Out: TBC • www.corsair.com • Price: TBC



High on Life

If there was a prize for the most popular game at Gamescom on social media, then *High on Life* would win it. The new game from *Rick and Morty* creator, Justin Roiland, became an instant hit in the convention center, thanks to a particularly profane set of weapons including guns and knives which spit out swear words encouraging you to dole out all sorts of damage to your foes. The love-it-or-hate-it sense of humor from Roiland's other work is present and correct, then, but the *Metroid Prime*-esque gameplay does mean that this should also have mass appeal beyond the profanities.
• Out: 13th December 2022
• www.squanchgames.com



© XBOX GAME STUDIOS, SQUANCH GAMES

Sonic Frontiers

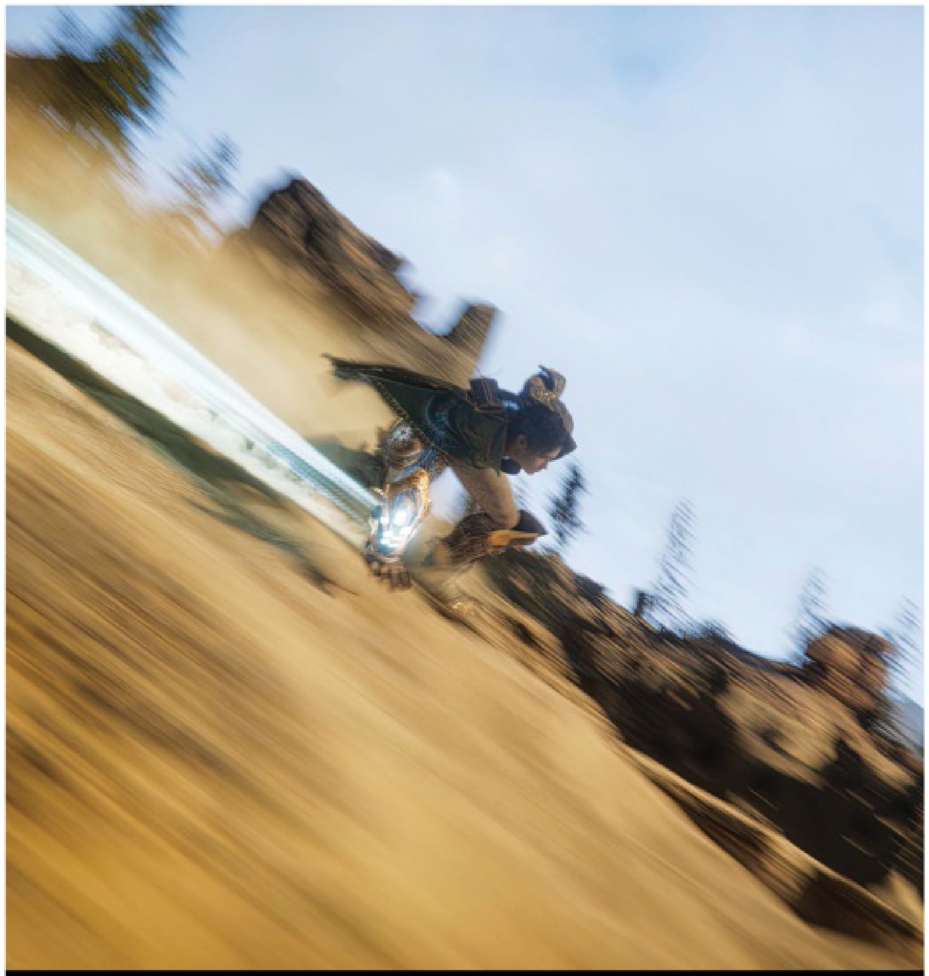
Yet another 3D *Sonic* game!? Previous entries in the series have taught us to proceed with caution when it comes to hyping them up, but our hands-on at the show left us with positive impressions. Don't expect anything revolutionary as it's very much in the vein of Dreamcast classic *Sonic Adventure*, but with a new open-world format and remixed versions of 2D and 3D *Sonic* levels.

- Out: 8th November
- frontiers.sonicthehedgehog.com

Bulwark: Falconeer Chronicles

The original *Falconeer* was an impressive technical and stylistic achievement, given the majority of the game was made by just one man. *Bulwark: Falconeer Chronicles* is an entirely new genre, a city builder set in that same universe. The idea is that you'll build out islands and then defend them from the airborne threats that will be familiar to players of the original game.

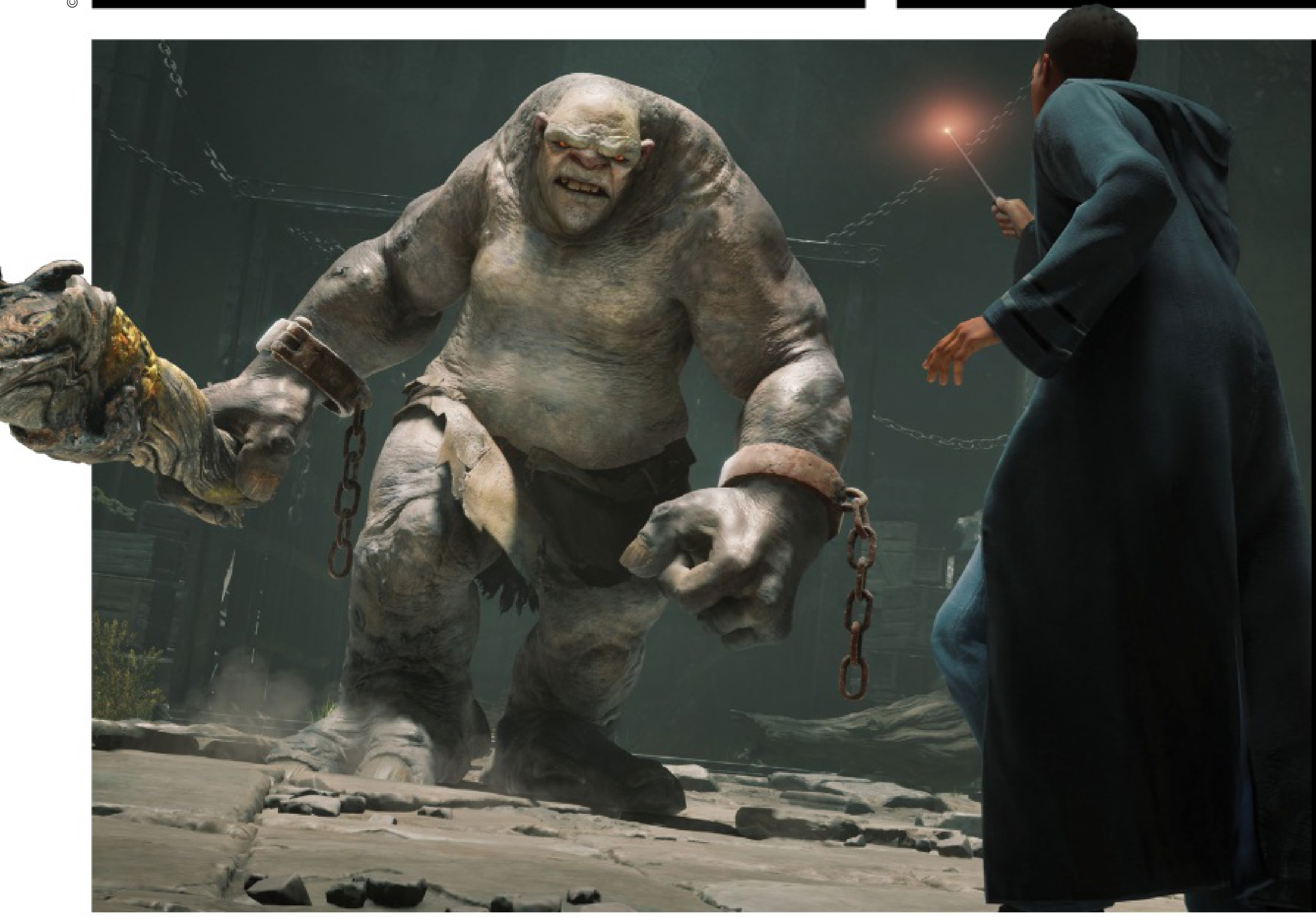
• Out: TBC • www.thefalconeer.com



Atlas Fallen

There are still relatively few games developed solely for next-gen platforms such as PS5, Xbox Series, and PC, with most still straddling console generations. The result is that only a handful of titles take true advantage of next-gen hardware. *Atlas Fallen* is one such title, a hugely impressive graphical showcase that could crudely be called a *Zelda: Breath of the Wild* clone, or more generously a *Journey*-esque sand-based adventure with huge beasts to fight, sword-based action, and fully cooperative gameplay mechanics.

• Out: 2023 • www.focus-entmt.com



Hogwarts Legacy

For Harry Potter fans, *Hogwarts Legacy* looks like the darkest slice of the Wizarding World since Alfonso Cuarón directed the *Prisoner of Azkaban*. The Gamescom footage showed how the gameplay will focus on the dark arts, and how you will become an expert in casting curses, dark magic, and generally inflicting pain. As anyone into JK Rowling's work knows, there's always the threat of good kids getting turned to the dark side, although the wizard zombies are a new entry into the Hogwarts Universe.

- Out: 10th February 2023
- www.hogwartslegacy.com

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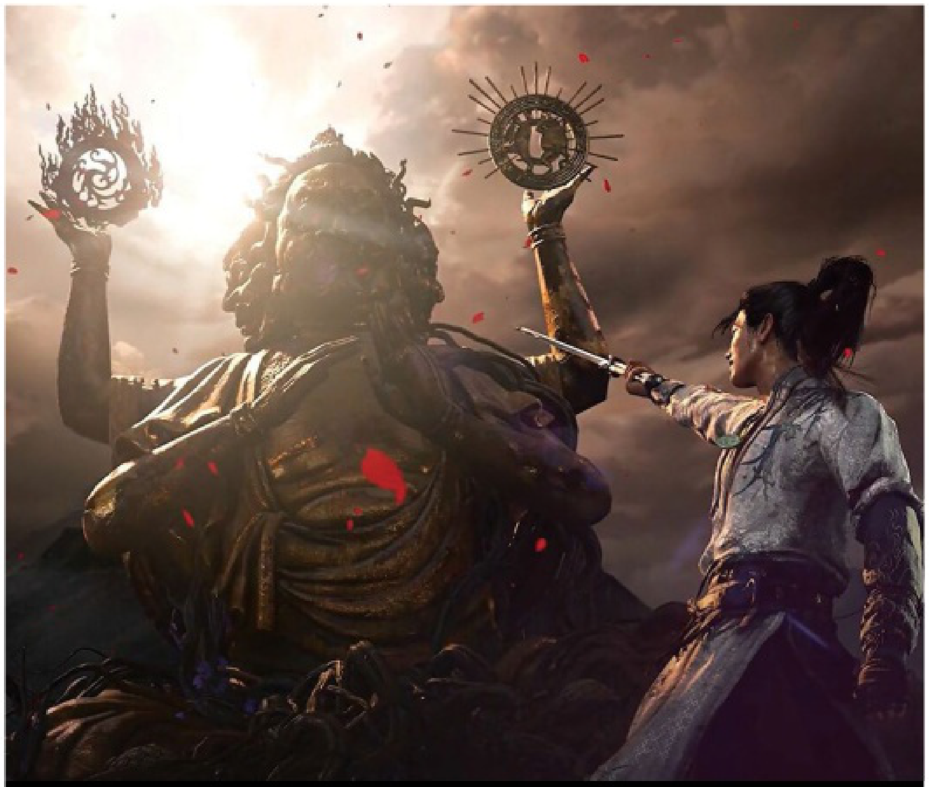
HIGH SPEED
Arcade Single Race
High Speed Ring
Next
benq

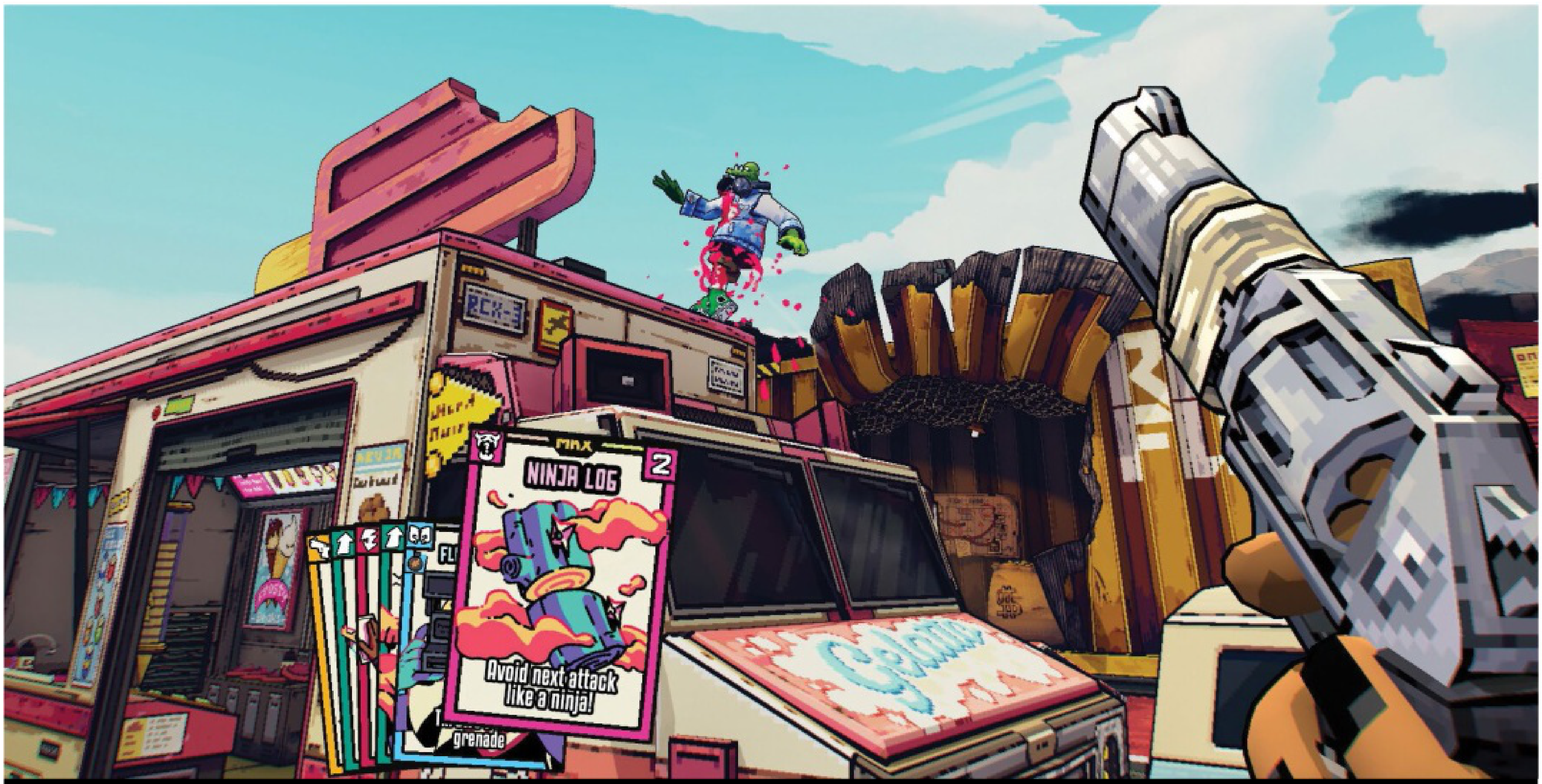
BenQ Morbiuz EX480UZ

BenQ has partnered up with LG for this 48-inch 4K OLED gaming monitor, which, truth be told, appears very similar to the Korean manufacturer's similar-size TVs. However, BenQ has added lots of gamer-friendly features, such as FreeSync Premium, a KVM switch, and genre-specific audio modes. We managed to play *Gran Turismo 7* on the screen and were impressed with the television's automatic HDRi mode, which offered gorgeous inky blacks and beautiful color reproduction.
• Out: October 2022 • www.benq.com • Price: $1,999



Where Winds Meet

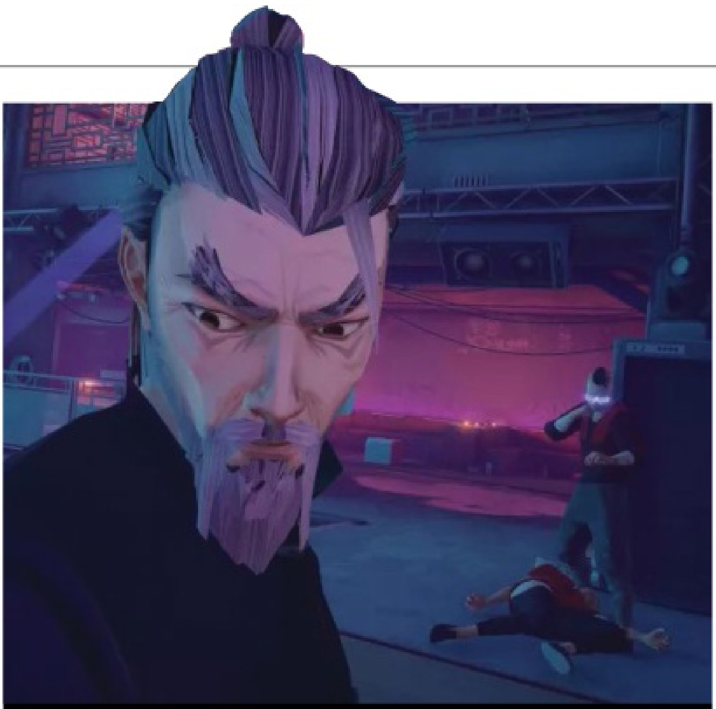
If you liked PS5-exclusive *Ghost of Tsushima* but wished it was set in medieval China and available on the PC, keep an eye out for this open-world RPG. The art is incredible but there are other interesting elements, such as Wuxia-style martial arts and the Ten Kingdoms period setting. There are some *Assassin's Creed* vibes to *Where Winds Meet*, such as horseback riding, combat, and exploration, although the weaponry includes swords and magic. You can also become a merchant, doctor, or explorer.
• Out: 2023 • N/A



Friends vs. Friends

If you're looking for a fun game to play with friends then keep an eye out for the appropriately named *Friends vs. Friends*. Each player goes into battle with a deck of cards that can be exchanged for weapons and buffs, some of which will improve your offensive capability and others that will hinder the other player. The idea is to build your deck to your tactical advantage, trying to out-strategize your opponent before each match. It's a simple premise accentuated by cel-shaded visuals and should be a multiplayer blast.
• Out: TBA • www.rawfury.com

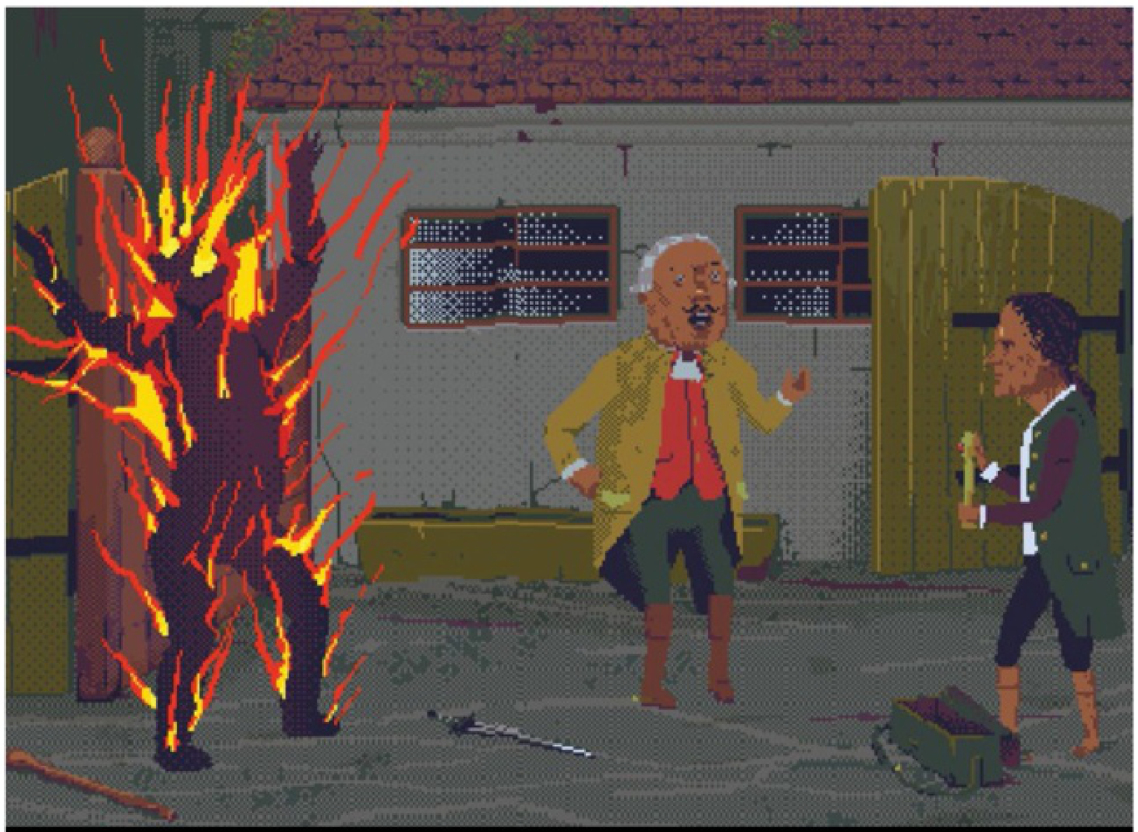
© RAW FURY, EVERSTONE STUDIO



Sifu (Summer Content Update)

Ultra-stylish martial arts action game *Sifu* was one of 2022's indie breakout hits, and more than six months on from its release it's still going strong within the community. The free summer update, which is available now, encourages players to come back to the notoriously difficult game with gameplay modifiers that allow you to switch up your runs through the game, as well as fun adaptations including low-gravity and slow-motion modes. There's also the much-requested improved scoring system, which evaluates your performance based on how well you're playing the game like an action movie.

• Out: Now • www.sifugame.com



The Case of the Golden Idol

The Case of the Golden Idol is one of those indie darlings that made a real splash at Gamescom among the development community in attendance. With its hand-drawn pixel art murder scenes set in the 18th Century, it certainly has an offbeat style all of its own, but the gameplay, whereby you click on clues to try and piece together the crimes, is reminiscent of *Return of the Obra Dinn*. The full game will boast 12 murders to investigate, all of which are interlinked. There's a demo now available on Steam if you want to check out what all the fuss is about.

• Out: Late 2022 • www.twitter.com/ColorGray7

Goat Simulator 3

Wait a minute, what happened to *Goat Simulator 2*? Well, it doesn't actually exist—just one more example of Coffee Stain Studios not taking anything seriously when it comes to its *Goat Simulator* franchise. It has been eight years since the release of the first game, however, and in the meantime, the averagely-reviewed title at launch has become something of a cult classic, thanks to its general irreverence and silliness. Underneath it all, this is still a party game where you play as an annoying goat, with the resulting mischief designed to appeal to Twitch streamers and party game players.

• Out: 17th November 2022 • www.goatsimulator3.com

Everywhere

The headline to *Everywhere* is that it's from famed *GTA* producer Leslie Benzies, and this is his first open-world game since *GTA V* almost a decade ago. It's hard to tell what the game might be from the trailer shown at Gamescom—it appears to take place across a variety of sci-fi-esque worlds, encompassing third-person platforming, shooting, and racing. But the scope looks ambitious—akin to something like *Ready Player One*, it's even been compared to the Metaverse. Our colleagues over at *PC Gamer* magazine called it "Roblox for grown-ups", which sounds pretty enticing to us.

• Out: 2023 • everywhere.game

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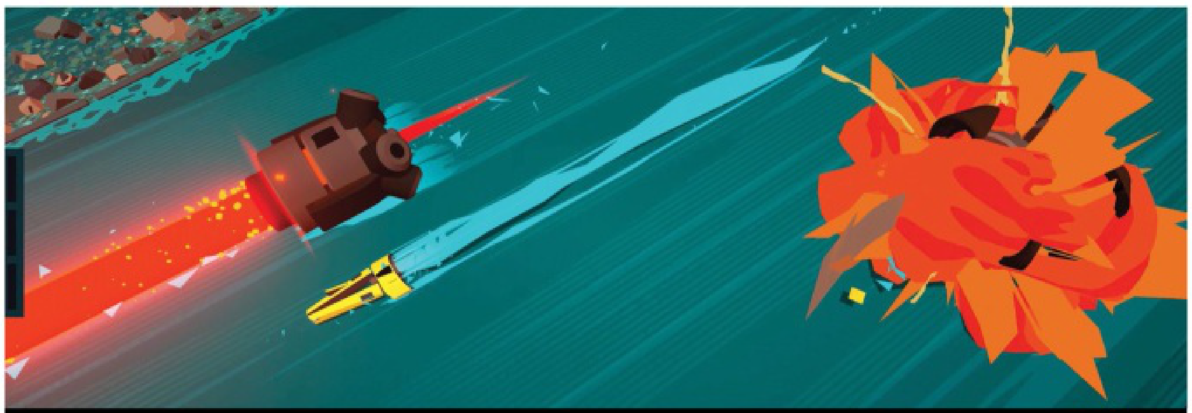
WD_BLACK PC SN850 NVMe SSD
www.wdblack.com
WD_BLACK SN850
Western Digital.

WD Black SN850X

The standard Western Digital Black SN850 was already one of our favorite SSDs for gamers and the SN850X ups the ante with a few extra features. A new controller means faster overall performance, there's a 4TB version for the first time, and also a heatsink version with RGB lighting. WD's software also enables a game mode to improve overall game performance, and the drive comes with a five-year warranty. Check out our full review on page 89 for more.

- **Out: Now** • **www.westerndigital.com**
- **Price: $160 (1TB), $290 (2TB), $700 (4TB)**



Swordship

Games conventions are great for finding those indie gems that might not otherwise have the marketing budget to make an impact. *Swordship* is one such title – described as a "dodge 'em up", it looks beautiful, has a great electronic soundtrack, and gives the same cool futuristic vibes as that other antigrav racer *Wipeout*. The whole game is about weaving around enemy fire and then using enemy weapons against them, all while racing at incredibly high speeds. We particularly liked the *Burnout Revenge*-style Takedown camera that highlights your best enemy kills.

- **Out: December 2022** • **thunderfulgames.com/games/swordship**

Vikings on Trampolines

D-Pad studios made a name for itself as the developer of the excellent *Owlboy*, released back in 2016. *Vikings on Trampolines* does exactly what it says on the tin, with players bouncing little Norse soldiers around in single-player, cooperative, and multiplayer challenges and minigames. The gameplay is incredibly accessible thanks to the fact it can be played one-handed, but hopefully, it won't take as long for the studio to make as *Owlboy*, which took nine years to see the light of day.

- **Out: TBA**
- **www.vikingsontrampolines.com**

The Great War: Western Front

Here on *Maximum PC*, we've always got time for a real-time strategy game, especially if it comes from many of the same team that made *Command & Conquer*. After releasing an excellent remaster of that game, developer Petroglyph Games announced this World War I RTS, which features much larger battles than *C&C* ever did, and positions it closer to something from the *Total War* series. While the subject matter dictates a more somber tone than *Command & Conquer*'s often campy theatrics, this looks like an enthralling strategy game for those who take such things seriously.

- **Out: 2023** • **www.playthegreatwar.com**

Forspoken

Square Enix's action RPG comes from Japan's Luminous Productions, who previously worked on *Final Fantasy XV*. *Forspoken* mixes parkour, magic, and even *Assassin's Creed*-style towers in a graphical showcase, which uses its fantasy setting to appeal to *Lord of the Rings* and *Game of Thrones* fans looking for a story-driven adventure.

- **Out: 24th January 2023**
- **forspoken.square-enix-games.com**

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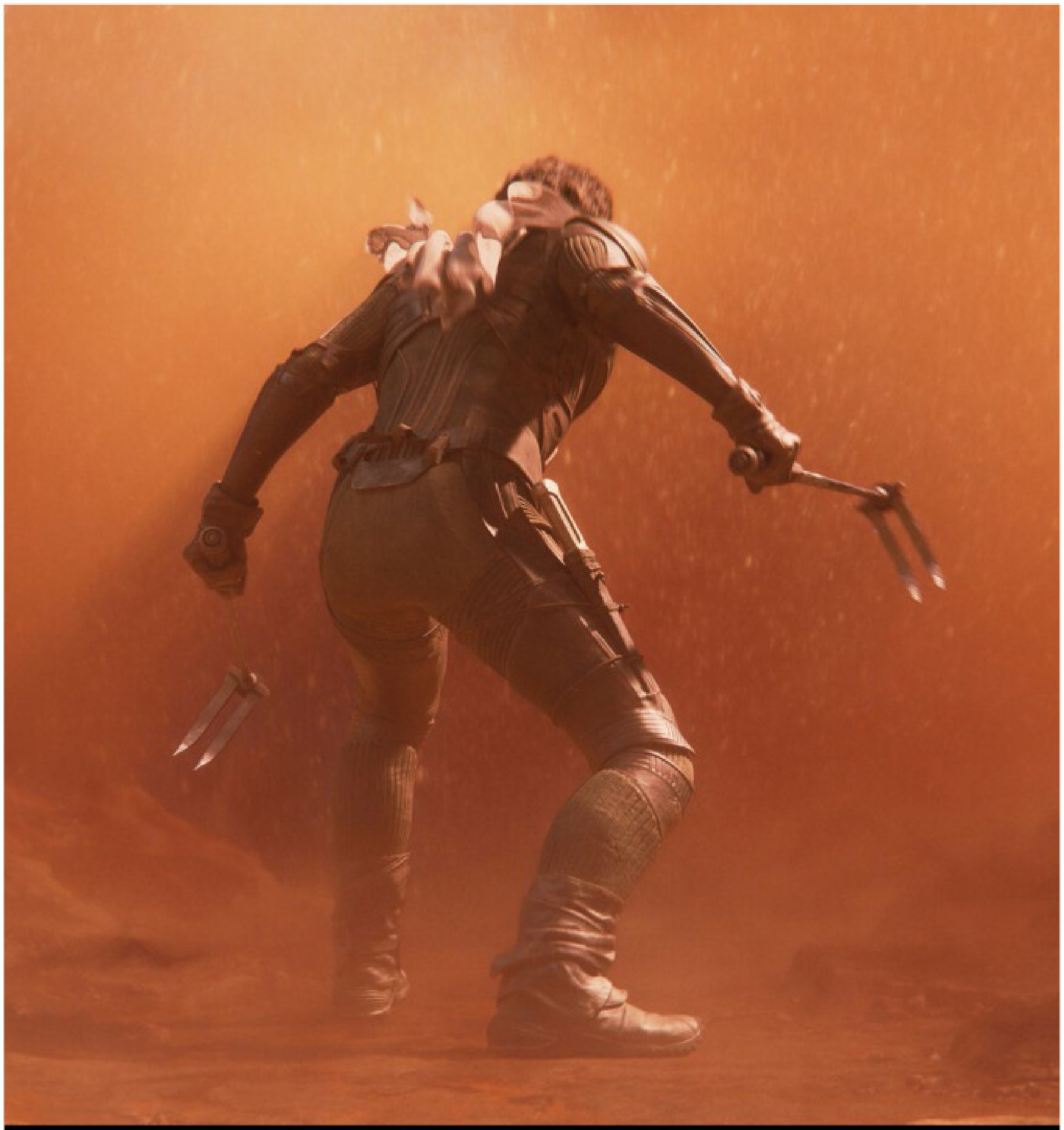
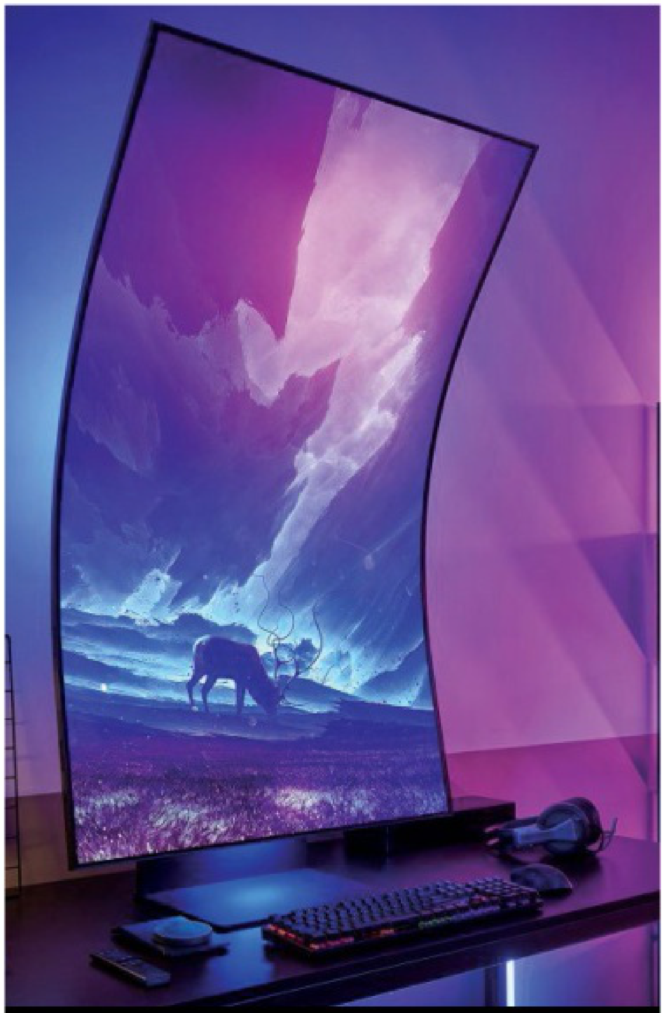


Dune Awakening

Last year's *Dune* film took Frank Herbert's apparently unfilmable novel and turned it into a highly successful blockbuster with a sequel on the way. The *Dune* universe is therefore now hot property, and Conan Exiles developer Funcom is building an open-world MMO set on the desert planet of Arrakis. Not much else is known at this stage, although it appears the main challenge of the game will be managing resources and taking on other players in order to survive. It's still early days, with no release date, but we can't wait to see this one emerge like a Sandworm when it's ready.
• Out: TBA • www.dunegames.com



Samsung Odyssey Ark

Samsung's Odyssey range of monitors has made a name for itself with fantastic ultrawide offerings, but the 55-inch Ark really takes the biscuit when it comes to size. Big enough to fill your entire peripheral vision in landscape, the monitor can also be turned vertically to offer what are essentially three smaller displays stacked on top of each other. Why? Well, so that streamers can game while keeping an eye on their broadcast windows, or gamers who want to play while keeping one eye on live sports.
• Out: Now • www.samsung.com
• Price: $3,500

Atomic Heart

Atomic Heart was first revealed in the form of concept footage over a decade ago, with a reveal trailer back in 2018 fanning the flames in terms of gamer anticipation. The Gamescom 2022 trailer focused on combat that felt like a combination of *Bioshock*, *Stalker*, and the *Metro* series, particularly because of the post-apocalyptic Russian setting. It's a beautiful-looking game that boasted the Nvidia logo at the end of the trailer, with more good news in the form of its release inclusion in Xbox Game Pass.
• Out: December 2022
• www.mundfish.com

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Discuss all things PC gaming with fellow readers at our official forums

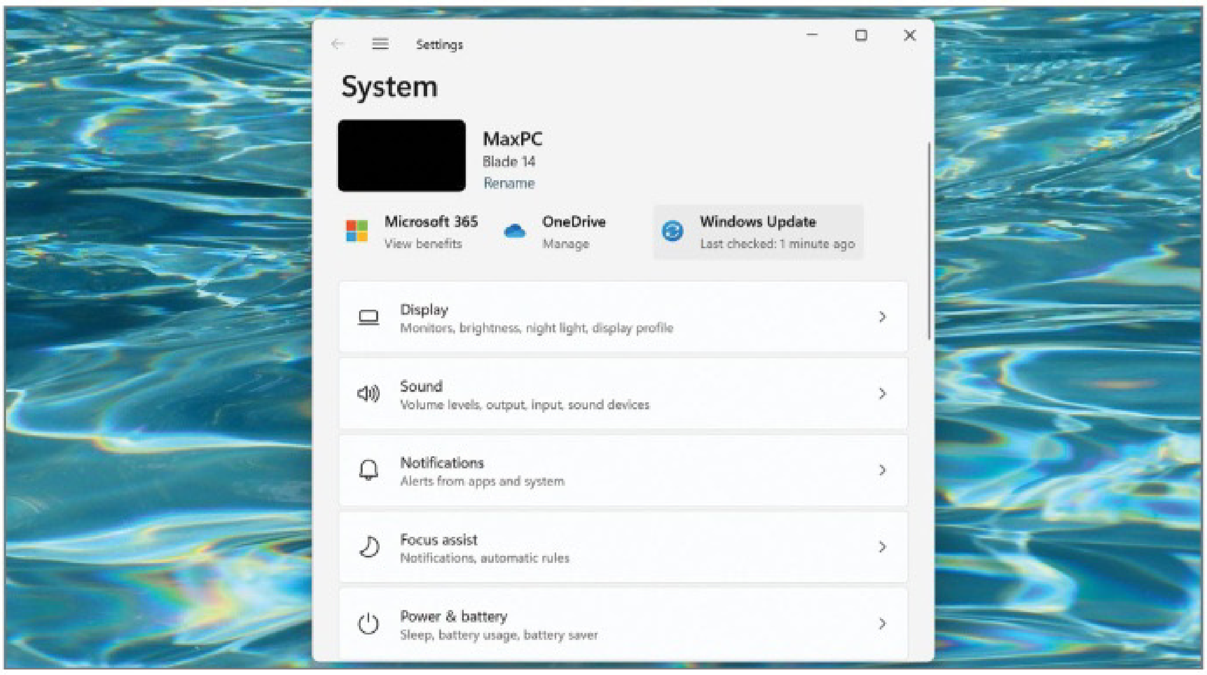
forums.pcgamer.com

PC GAMER

HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

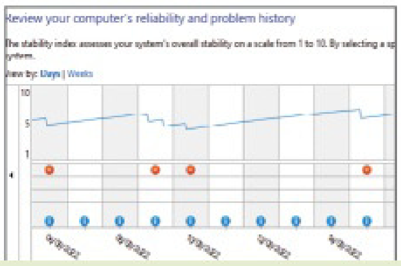
TIP OF THE MONTH


Settings
System
MaxPC
Blade 14
Rename
Microsoft 365
View benefits
OneDrive
Manage
Windows Update
Last checked: 1 minute ago
Display
Monitors, brightness, night light, display profile
Sound
Volume levels, output, input, sound devices
Notifications
Alerts from apps and system
Focus assist
Notifications, automatic rules
Power & battery
Sleep, battery usage, battery saver

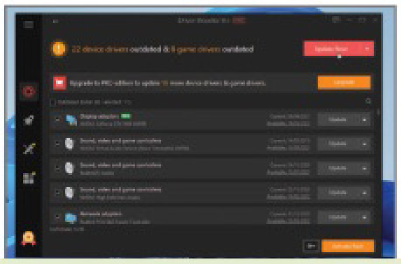
SETTINGS MATTER

When you are working or playing games in full-screen mode, getting back to your desktop screen isn't always the easiest or quickest thing to do. Neither is returning to your settings window, especially if you haven't already added it to your taskbar. But if you need to interrupt your game for another task or to tweak the settings quickly, an easy way to dive straight into your settings menu is to press the 'Windows Key' + 'I'.

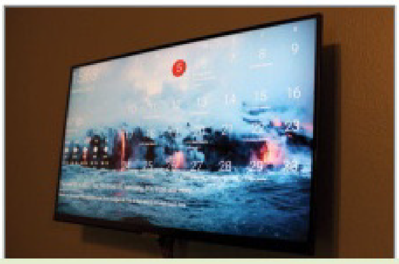
MAKE – USE – CREATE



64
Fix common PC problems with Windows 11.



68
Locate those hard-to-find drivers and update them.



70
Turn a monitor into a digital dashboard.

©MICROSOFT, DRIVER BOOSTER FREE

SAM LEWIS
STAFF WRITER

A ROW OF SAINTS

Open-world titles have to be my favorite genre of games. The sense of freedom, endless possibilities, gripping storylines, and the sheer amount of carnage you can create are truly immersive. Yet, like most things in life, the things you love the most can also disappoint you.

Without meaning to get too deep, we all know how *GTA: The Trilogy* remastered turned out—a huge buzz followed by an even bigger letdown. So with that in mind, I've tried not to get too excited for the latest installment in the *Saints Row* franchise. However, that's been pretty hard to do as the older *Saints Row* games were a big part of my PlayStation 3 days and still give me a nostalgia hit today.

At the time of writing, the latest *Saints Row* hasn't been well received by critics, so I don't hold out too much hope. But it aims to go back to basics, ditching the silliness that had crept into the recent games. I liked how the series was essentially a whacky alternative to *GTA*, but when that was poorly executed it hampered my enjoyment of the franchise.

Regardless, it's piqued my interest enough to try it out and should be enjoyable enough to bide my time until I move. Yes, I am still in limbo mode with moving properties.

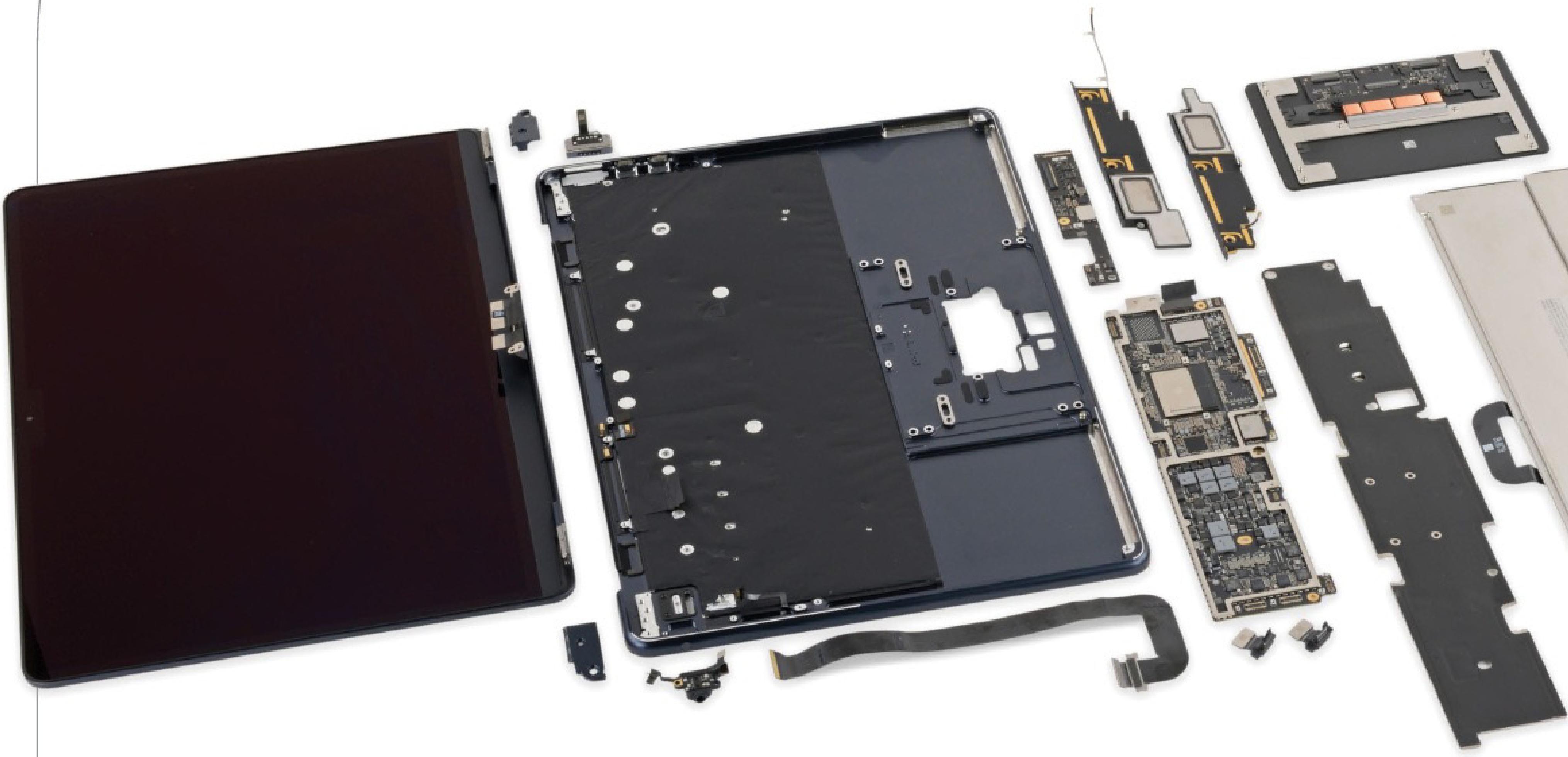
↘ submit your How To project idea to: editor@maximumpc.com

IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

MacBook Air with



The compact main board looks similar to the one in the iPad, which it kind of is now Apple is using the same architecture with Apple Silicon chips.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products.
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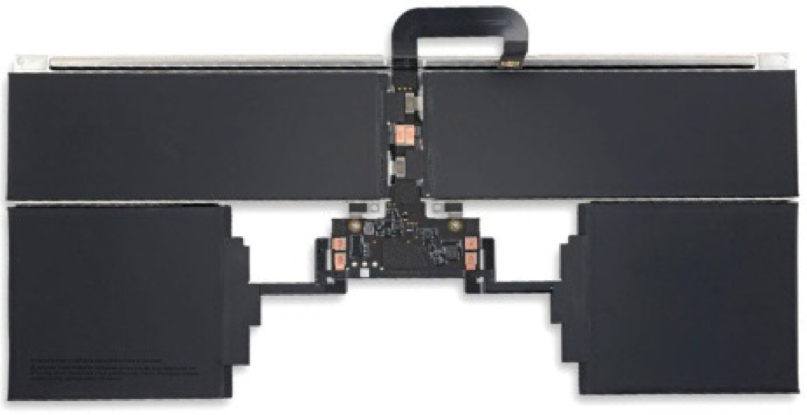
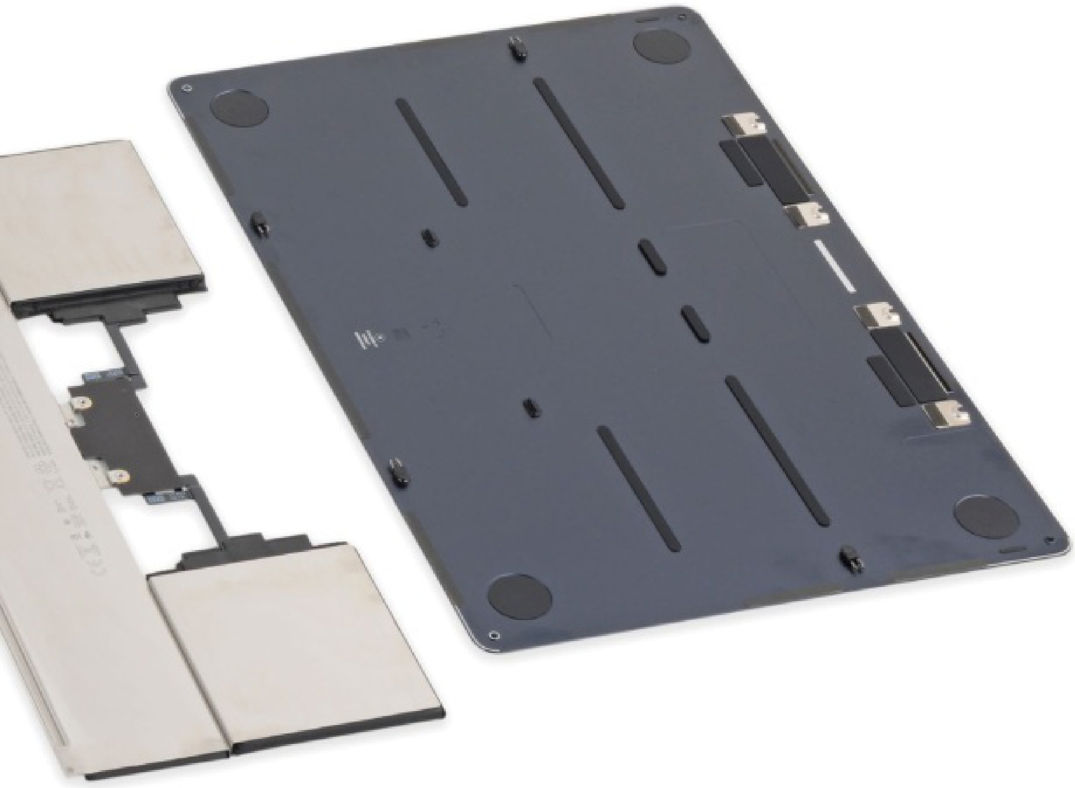


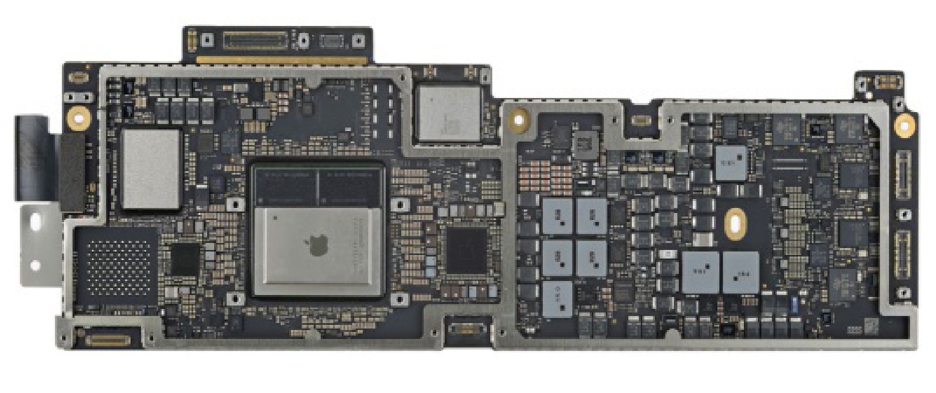
While the Air's battery has four cells, the top two are in parallel and the bottom two are in series, making it operate like a three-cell battery. Don't ask us why, though.

There are four screws to remove on this year's Air, rather than ten previously. Don't be afraid when pulling it off, it takes some force.

With no fans or heat management system, Apple's MacBook Air may get a little warm.

M2 chip





BACKGROUND

Apple's small but mighty ultraportable laptop deploys the latest silicon to impressive effect across creative work and even gaming.

MAJOR TECH SPECS

- Apple M2 chip 8-core CPU (Four performance, four efficiency)
- 8-core or 10-core GPU
- 8GB RAM (configurable to 24GB)
- 13.6-inch IPS display with 2560x1664 native resolution
- 52.6-watt-hour lithium-polymer battery
- Ports: 2x Thunderbolt/USB 4, MagSafe 3 charging, 3.5mm jack
- 256GB SSD (configurable to 2TB)
- 802.11ax Wi-Fi 6 and Bluetooth 5.0
- 1080p Webcam
- Dimensions: 0.44 x 11.97 x 8.46in (1.13 x 30.41 x 21.5cm)
- Weight: 2.7lbs (1.24kg)

KEY FINDINGS

- The latest Macbook Air with M2 chip is thinner and lighter than its M1 predecessor, and also has a bigger display. There's an extra port in the form of the popular MagSafe connector. Speaker grilles replace the old perforated case design, with sound pumping out between the case and the display.

- You only need to remove four screws to get into the Macbook Air, but it requires some tugging to get the bottom panel away from the chassis. Remove the tiny screws and brackets and open a trap door to disconnect the battery from the logic board. It is now safe to start excavating the main part of the system. So far, not so difficult, compared with previous Macbook Airs.

- Now start removing items from the logic board, such as screws, brackets, and other fiddly items. Then take off the clip-on shield to remove the logic board. Here, you'll discover the Macbook Air's heat management, or should we say, lack of.

- Once the logic board is out, you're left with the metal shielding. There's no heat spreader, just a large gap, a lot of thermal paste, and some graphite tape. While the M2 is efficient, that's concerning if you regularly put the Air through its paces. Maybe the M2 Air is secretly an iPad? Or maybe Apple lets it run hot?

- Looking at the logic board, we find mostly soldered-down chips, affecting the upgradeability potential. These include the octa-core M2 plus unified memory package plus integrated GPU, a single 256GB NAND flash memory chip (with space for a second unit), and a USI chip that is likely just Wi-Fi and Bluetooth. There's an accelerometer, the same as in Apple's new Studio Display, and an Apple-made Thunderbolt 3 driver.

- Other accessible items include the trackpad, which is freed by loosening a few screws and washers. There are also four speakers that can be accessed via some screws, but also some hinge covers that are a nightmare to access. Other components, such as the USB-C port, headphone jack, and MagSafe connector are modular and not glued down, so should be easy to replace. The audio board is thin and easy to get out, as is the TouchID button, which comes out easily through the top case.

- The battery is attached to the case with stretch-release adhesive. The battery is in a U-shape design with four cells at a total rated capacity of 52.6Wh—enough for up to 15 hours of wireless web use thanks to Apple's optimizations.

- Repairability score: 4 out of 10 (10 is easiest to repair). It's easier to open up this year's Air, thanks to fewer screws, but everything is tucked away neatly, so it isn't easy to access the important components inside. You can't replace or upgrade the SSD or Wi-Fi chip, but you could replace the battery, trackpad, speakers, and keyboard. Apple has promised to release spare parts for this Air in the future, which counts as progress.

Fix PC problems with Windows 11

YOU'LL NEED THIS

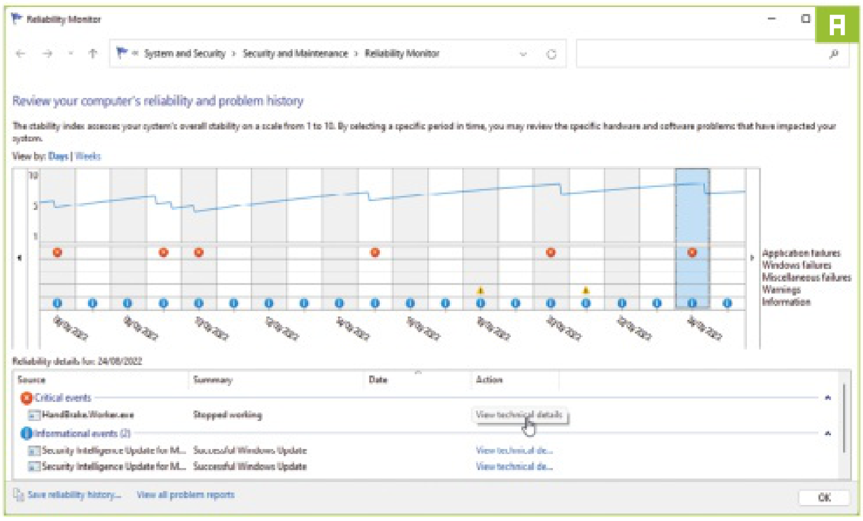
WHOCRASHED HOME EDITION
(www.resplendence.com/whocrashed)

TWEAKING.COM WINDOWS REPAIR TOOL
(www.tweaking.com)

GOT A PROBLEM WITH YOUR PC? The answers to your woes lie somewhere buried deep inside Windows itself, you just need to know where to find them. Windows 11 may not introduce any new troubleshooting tools to the mix, but it continues to support tried and tested tools, including Device Manager, Event Viewer, and a host of troubleshooters.

We'll take an in-depth look at these as well as some other useful tools. Reliability Monitor is built into Windows, while the third-party tools we showcase—WhoCrashed and Tweaking.com's Windows Repair tool—are included because they provide convenient access to system logs and tools such as System File Checker and Windows' powerful disk-checking tools.

If the tools featured can't provide a solution to your problem, they will at least arm you with lots of useful information with which you can go hunting for solutions elsewhere using the power of the web. The answers to your problems lie hidden somewhere, either within your PC or out on the wider internet, and in the unlikely event you're left stumped, you can always contact us directly for help—email doctor@maximumpc.com with your problem and remember to include as much information as you can to help us to help you. **–NICK PEERS**



1 GET A SYSTEM HEALTH OVERVIEW

If you're plagued by a poorly performing system, but don't know exactly where to look, type 'reliability' into the Search box and click 'View reliability history' to open the Reliability Monitor—yes, it's still there in Windows 11. This provides an overview of your system's stability over the past 12 months—you'll get an overall rating of 1 to 10, updated daily. Whenever failures or warnings are recorded in the Events log, your rating drops accordingly. The longer it goes without problems, the higher the ratings go.

» Of more use are the summaries beneath the rating line graph—here, you'll find a list of notable events for the selected day. Look for those where failures or warnings have been recorded, then select the most recent day on which they occurred [**Image A**]. You'll get a summary of the problems recorded, including the application name and a short explanation, plus a date and time of the event. Click 'View technical details' for a fuller description. Make a note of key details, such as the application name, any 'faulting modules', and exception codes, then skip to step 3 to see if you can track down any potential solutions online.

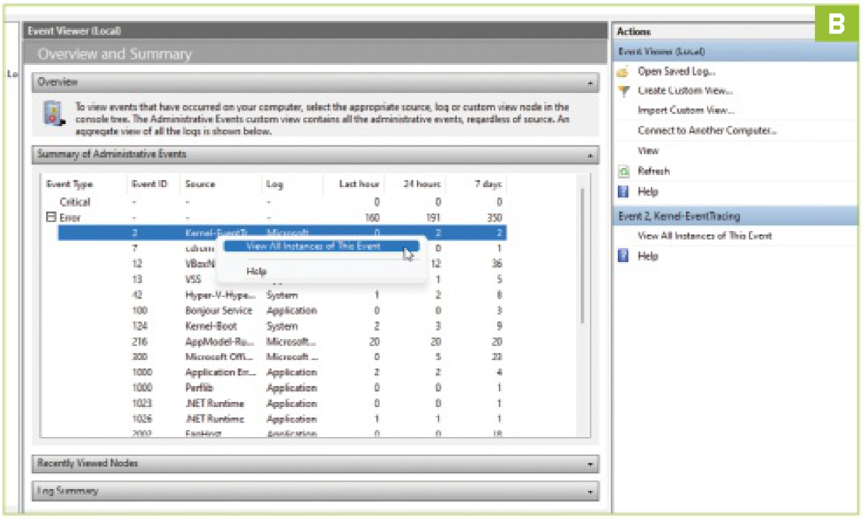
2 CHECK EVENT VIEWER

While Reliability Monitor will highlight critical problems, Event Viewer offers a broader overview of your system. This handy tool can be launched via a search for 'event' or you can simply press Win + R, type eventvwr and hit Enter. Event Viewer provides access to your system logs, which chronicle everything from mundane day-to-day events to warnings, error messages, and 'critical' events, which often include crashes (assuming the system is able to log something when the crash occurs. Skip to the next step if you suffer a blue-screen crash).

» Click '+' next to a section to expand it and view a summary of the events recorded. Focus on events that last occurred around the time your problem manifested itself using the three date/time ranges (Last hour, 24 hours, 7 days) for potential matches [**Image B**].

» Double-click an event to open its Summary page, then use the annotation to help identify possible events that correlate to the problem you're investigating. In many cases, the event will have occurred multiple times. Review all instances, focusing on the time and date each instance occurred, which you may be able to link directly to your problem.

» Don't assume this single event is the only one linked to your issue, however. Go through all event types under 'Critical', 'Error', and also possibly 'Warning' to see if multiple events are occurring at the same time. Make a note of each one, then read on to discover how to examine each one in more depth.



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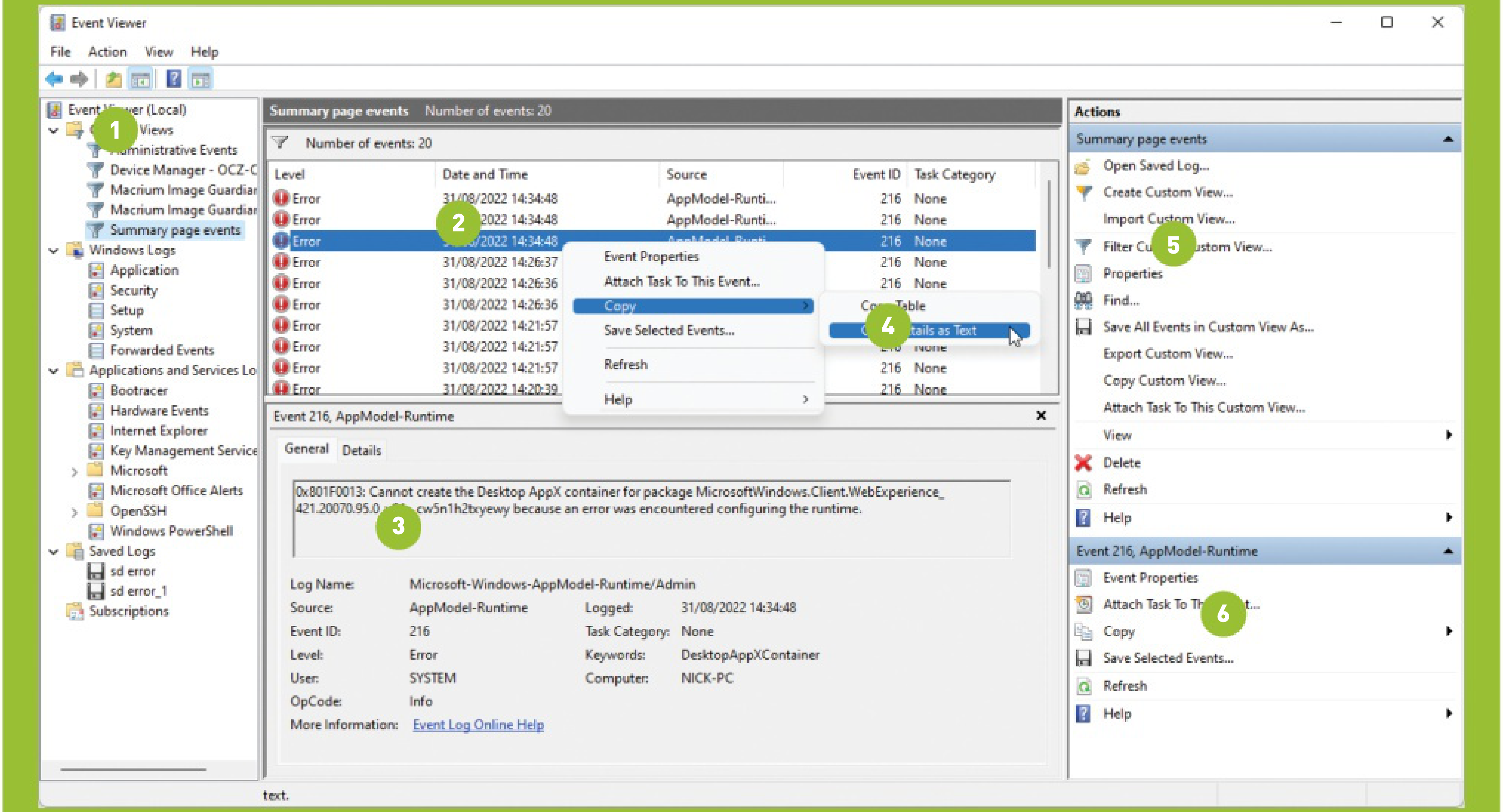
NAVIGATE EVENT VIEWER


Event Viewer
File Action View Help
Event Viewer (Local)
Views
Administrative Events
Device Manager - OCZ-C
Macrium Image Guardian
Macrium Image Guardian
Summary page events
Windows Logs
Application
Security
Setup
System
Forwarded Events
Applications and Services Lo
Bootracer
Hardware Events
Internet Explorer
Key Management Service
Microsoft
Microsoft Office Alerts
OpenSSH
Windows PowerShell
Saved Logs
sd error
sd error_1
Subscriptions
Summary page events Number of events: 20
Number of events: 20
Event Properties
Attach Task To This Event...
Copy
Save Selected Events...
Refresh
Help
Copy Table
Copy Details as Text
Actions
Summary page events
Open Saved Log...
Create Custom View...
Import Custom View...
Filter Current Custom View...
Properties
Find...
Save All Events in Custom View As...
Export Custom View...
Copy Custom View...
Attach Task To This Custom View...
View
Delete
Refresh
Help
Event 216, AppModel-Runtime
Event Properties
Attach Task To This Event...
Copy
Save Selected Events...
Refresh
Help
1
2
3
4
5
6
text.

Level	Date and Time	Source	Event ID	Task Category
Error	31/08/2022 14:34:48	AppModel-Runti...	216	None
Error	2022 14:34:48	AppModel-Runti...	216	None
Error	2022 14:34:48		216	None
Error	31/08/2022 14:26:37		216	None
Error	31/08/2022 14:26:36		216	None
Error	31/08/2022 14:26:36			
Error	31/08/2022 14:21:57			
Error	31/08/2022 14:21:57			None
Error	31/08/2022 14:21:57		216	None
Error	31/08/2022 14:20:39		216	None

Event 216, AppModel-Runtime

General Details

0x801F0013: Cannot create the Desktop AppX container for package MicrosoftWindows.Client.WebExperience_421.20070.95.0 cw5n1h2txyewy because an error was encountered configuring the runtime.

Log Name: Microsoft-Windows-AppModel-Runtime/Admin
Source: AppModel-Runtime
Logged: 31/08/2022 14:34:48
Event ID: 216
Task Category: None
Level: Error
Keywords: DesktopAppXContainer
User: SYSTEM
Computer: NICK-PC
OpCode: Info
More Information: Event Log Online Help

1. FILTER VIEW
Event Viewer allows you to examine specific parts of your system by browsing the available list of logs. Alternatively, you can create your own custom views.

2. ERROR FREQUENCY
In isolated cases, errors and warnings can be ignored, but if they keep cropping up it's a good idea to investigate them further.

3. EVENT DETAILS
Try to include as much detail as the log gives you in your searches: Event ID, source (or filenames), and any error codes, plus key information from the description.

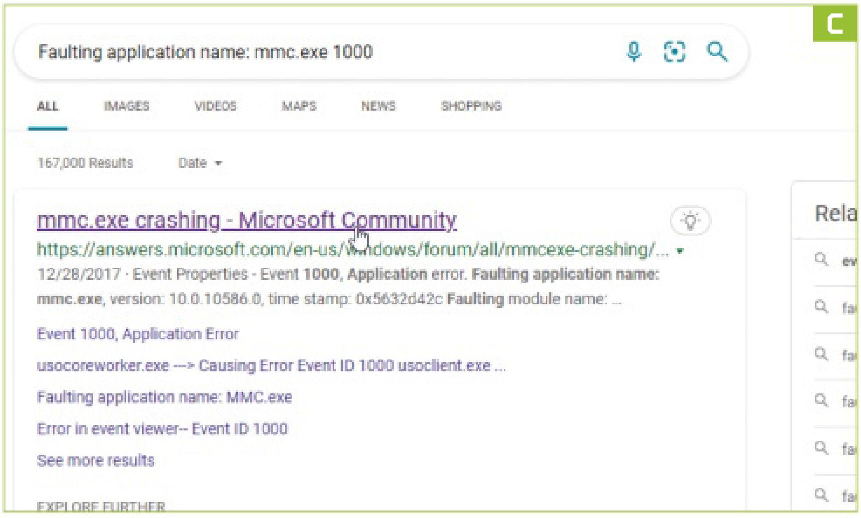
4. ASK OTHERS
If all else fails, right-click the event to copy its details to the clipboard. You can paste this into an email to the Doctor or a web forum post when asking for help.

5. FILTER CURRENT VIEW
When viewing specific logs, click 'Filter Current...' to determine what's shown—for example, only critical, warning, and error events, which is where most problems are recorded.

6. CREATE ALERT
By clicking 'Attach Task To This Event' (see the box) you can receive an on-screen alert whenever the system records this event in the future.

3 SEARCH FOR HELP

Make a note of the description—the Details tab provides more technical data for those who may need it later. You'll see an 'Event Log Online Help' link at the bottom of the General tab, but this has long since stopped working. From here on, you're relying on third-party help to dig deeper into your problem.


C
ALL
IMAGES
VIDEOS
MAPS
NEWS
SHOPPING
Rela

Faulting application name: mmc.exe 1000

167,000 Results Date

mmc.exe crashing - Microsoft Community
https://answers.microsoft.com/en-us/windows/forum/all/mmcexe-crashing/...
12/28/2017 · Event Properties - Event 1000, Application error. Faulting application name: mmc.exe, version: 10.0.10586.0, time stamp: 0x5632d42c Faulting module name: ...

Event 1000, Application Error
usocoreworker.exe ---> Causing Error Event ID 1000 usoclient.exe ...
Faulting application name: MMC.exe
Error in event viewer-- Event ID 1000
See more results

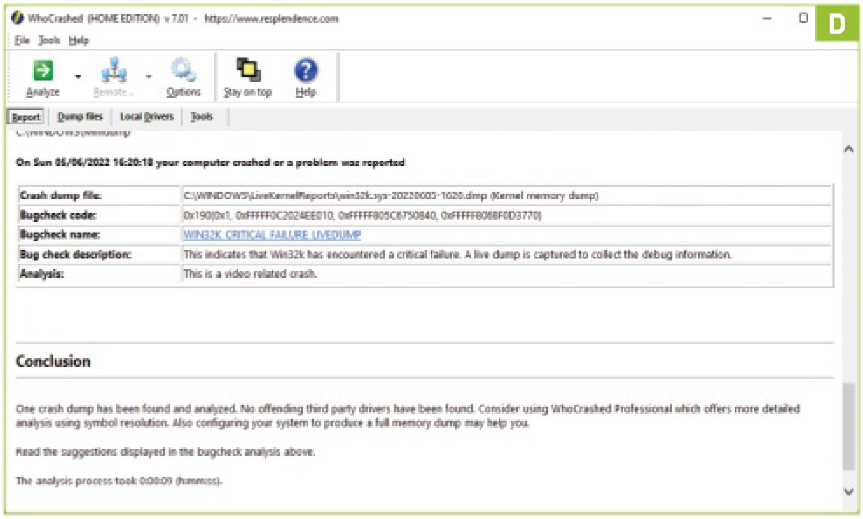
EXPLORE FURTHER

» Make a note of the Event ID, Source, and description under the General tab in Event Viewer, then type these into a search engine (Bing or Google are best) and see what results come up [**Image C**]. You may find more troubleshooting information via a web page or forum.

» If too few results are returned, try searching for fewer words or omitting the Source or Event ID from your terms. If too many results come back, try narrowing it by including more information. For example, try to include any specific references to filenames in the event log or provide more general information, such as your version of Windows, hardware device, or software program.

4 A DEEPER DIVE INTO EVENT VIEWER

What if you can't find the information you're looking for? It's likely the events you need to track are buried away. Try manually browsing the available logs to narrow your search. Expand Windows Logs in the left pane where you'll find logs organized into categories. Use Applications to search for program-related problems and System for Windows and hardware.


D
WhoCrashed (HOME EDITION) v 7.01 - https://www.resplendence.com
File Tools Help
Analyze
Remote
Options
Stay on top
Help
Report
Dump files
Local Drivers
Tools

On Sun 05/06/2022 16:20:18 your computer crashed or a problem was reported

Crash dump file:	C:\WINDOWS\LiveKernelReports\win32k.sys-20220605-1620.dmp (Kernel memory dump)
Bugcheck code:	0x190(0x1, 0xFFFFF0C2024EE010, 0xFFFFF805C6750840, 0xFFFFF8068F0D3770)
Bugcheck name:	WIN32K_CRITICAL_FAILURE_LIVEDUMP
Bug check description:	This indicates that Win32k has encountered a critical failure. A live dump is captured to collect the debug information.
Analysis:	This is a video related crash.

Conclusion

One crash dump has been found and analyzed. No offending third party drivers have been found. Consider using WhoCrashed Professional which offers more detailed analysis using symbol resolution. Also configuring your system to produce a full memory dump may help you.

Read the suggestions displayed in the bugcheck analysis above.

The analysis process took 0:00:09 (h:mm:ss).

» Logs record all manner of information, though much of it is irrelevant when troubleshooting a problem. Click the Filter Current Log button in the right-hand pane to filter the list in different ways: by the time it occurred, the type of event (focus on critical, error, and warning), Event sources, IDs, keywords, or any various combinations of these. Click OK when that's done.

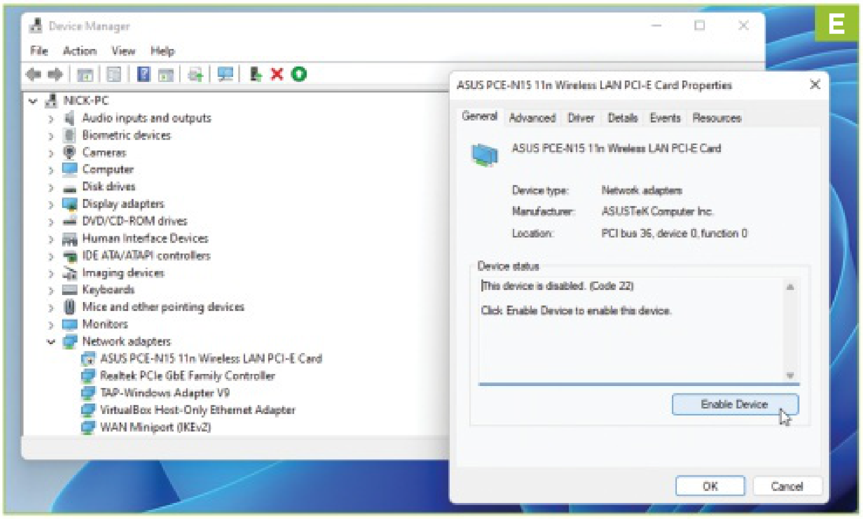
» If you want to create a filter that provides you with information across multiple logs or wish to create a filter you can easily access in the future, click Create Custom View under 'Actions'. It works in the same way as the filter—to monitor more than one log with your custom view, click the Event logs dropdown menu and tick the logs you wish to include.

» Click OK, then give your custom view a suitably descriptive name and choose where to save it within the Custom Views tree in the left-hand pane. Going forward you'll be able to access this view at any time directly from here—it's the perfect shortcut for targeted troubleshooting that will take an extended period to monitor and act upon.

5 TROUBLESHOOT BLUE-SCREEN CRASHES

Blue-screen errors, also known as STOP errors, can be a pain to troubleshoot, particularly if you're not quick enough to record the details before Windows reboots and attempts to bypass the problem. That's where a free tool called WhoCrashed Home Edition (www.resplendence.com/whocrashed) earns its corn.

» Once installed, it's capable of analyzing the system crash logs of your PC to produce a more coherent report you can use to troubleshoot. After installing, launch the program and click Analyze. Once complete, scroll down the Report window, where you'll be greeted with a list of all crash dumps on your system, complete with date and time (for corroboration). You'll see the usual technical information, including bugcheck codes and name, which is displayed on the blue screen after a crash and before your PC reboots.


E
Device Manager
File Action View Help
NICK-PC
Audio inputs and outputs
Biometric devices
Cameras
Computer
Disk drives
Display adapters
DVD/CD-ROM drives
Human Interface Devices
IDE ATA/ATAPI controllers
Imaging devices
Keyboards
Mice and other pointing devices
Monitors
Network adapters
ASUS PCE-N15 11n Wireless LAN PCI-E Card
Realtek PCIe GbE Family Controller
TAP-Windows Adapter V9
VirtualBox Host-Only Ethernet Adapter
WAN Miniport (IKEv2)
ASUS PCE-N15 11n Wireless LAN PCI-E Card Properties
General
Advanced
Driver
Details
Events
Resources
Enable Device
OK
Cancel

ASUS PCE-N15 11n Wireless LAN PCI-E Card

Device type: Network adapters
Manufacturer: ASUSTeK Computer Inc.
Location: PCI bus 36, device 0, function 0

Device status

This device is disabled. (Code 22)

Click Enable Device to enable this device.

» Crucially, you'll also be given a description and an analysis of the crash [**Image D**], which serve to help you understand why it occurred and what the likely culprit is. From here, you can click the bugcheck name to launch a Google search for articles and forum posts related to it and see what driver files are currently loaded (click Local Drivers).

» Take the time to visit the Tools section, where you'll find shortcuts to key system tools and settings like Event Viewer and System File Checker. You'll notice certain advanced options, such as the Crash Dump Test, or the ability to stop Windows from deleting memory dump files, are restricted to the Pro version, which at the time of writing costs around $35. For most people, however, the free Home version is sufficient for your troubleshooting needs.

6 FIX DRIVER ISSUES

Whether you simply want to verify the state of your drivers or strongly suspect a driver is the cause of a particular problem, then Device Manager is your go-to tool. Press Win + R, type devmgmt.msc and hit Enter to launch it.

» Any obvious problems should immediately be highlighted—look for entries with a yellow exclamation mark or a red cross next to them. Double-click an entry to open its own Properties window where you'll be given a brief summary of the problem under 'Device status' in the General tab. You can also review the device's entry in the system logs via the Events tab.

» Some basic issues can be resolved from the General tab. For example, if the device has somehow been disabled, you'll be prompted to click the 'Enable Device' button to restore it [**Image E**]. In most cases, however, you'll see an error code and associated message—for

STAY ALERT(ED)

Event Viewer allows you to create alerts that are triggered when specific events occur. This can prove useful for troubleshooting underlying problems as you may find a seemingly unrelated event is triggering the error or get an early warning that something is about to happen. Once you have located the event you wish to monitor, right-click it and choose 'Attach Task to This Event…'

Change the name to something you will recognize in Task Scheduler (see next step), then click Next twice. Neither email nor 'display a message' options work, so leave 'Start a program' selected and click Next. Type 'msg' into the Program/script box, then type * followed by your message (eg. '* Error Alert') into the 'Add Arguments' box. Click Next → Finish → OK.

You may no longer want that alert popping up, hopefully when you have fixed the problem. To remove it, open Task Scheduler—type 'scheduler' into the Search box and click 'Task Scheduler', or press [Win] + [R], type 'control schedtasks' and click OK. Expand Task Scheduler Library → Event Viewer Tasks, right-click the alert and choose Delete then Yes.

example, 'This device isn't configured correctly. (Code 1)', or 'The drivers for this device are not installed. (Code 28)'.

» Some driver issues (codes 14 and 38) can be fixed with a simple reboot, while others that appear to be driver-related can sometimes be resolved by simply removing and reinstalling the device using its current drivers. Close the Properties box, then right-click your malfunctioning device and choose 'Uninstall device'. Once complete, restart your PC—the device should be automatically detected and drivers reinstalled, which you can confirm after restarting by opening Device Manager again.

» If the problem persists, right-click the device again and choose 'Update driver' followed by 'Search automatically for updated driver software' to see if a newer driver is available via Windows Update. If no driver is found, check out our tutorial on finding and installing drivers from other sources (see page 70).

» Other errors usually provide some advice on what to do next, but if you're still struggling to fix the problem make a note of the device name and include both it and the error code number in a web search to see if you can find additional help online—for example, 'AMD USB 3.10 eXtensible Host Controller code 12.'

7 MORE DEVICE MANAGER FIXES

A hardware device's Properties tab contains other useful information that may help you troubleshoot the problem. The Driver tab provides detailed information about the installed driver such as its date, version, and where it came from.

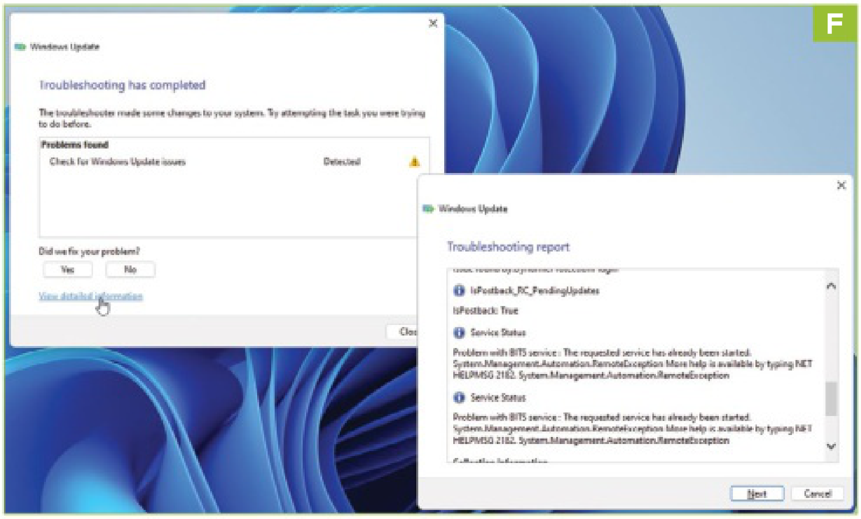
» Those listing Microsoft as a provider and Windows as the digital signer are WHQL-certified drivers available through Windows Update. These are the best choice for prioritizing stability over performance, but if you suspect a recent driver update is the cause of your problem, try the 'Roll Back Driver' button. If it's grayed out, you're either using your manufacturer's drivers or the earliest version in its WHQL-certified form.

» The Details tab lets you examine various parts of the hardware device in more detail. Many properties listed are beyond most people's skill set, but you may get some useful info from properties like 'Device description' or 'Installation date'.

» Look out for additional tabs depending on the type of device. For example, input devices like keyboards and mice have a 'Power Management tab' where you might be able to resolve issues with your computer unexpectedly waking up when put to sleep. Hard drives come with a Policies tab where you can optimize the drive for quick removal or better performance. Look out too for a Volumes tab where clicking Populate can help you match a physical drive to its Windows' drive letter.

8 ACCESS WINDOWS TROUBLESHOOTERS

Windows provides a series of troubleshooters spanning a wide set of issues. In Windows 11, they're configured to pop up when Windows detects specific issues—each troubleshooter is designed to search for specific issues within a set topic (for example, Internet Connections or Playing Audio), then offer to perform recommended fixes to try and fix the problem. It's then a case of following the wizard and answering any specific questions. If you see an 'Advanced' option, it's worth expanding this to see if there's any additional configuration available, such as an option to run the troubleshooter with administrator privileges for deeper access to the system.



Windows Update

Troubleshooting has completed

The troubleshooter made some changes to your system. Try attempting the task you were trying to do before.

Problems found

Check for Windows Update issues Detected

Did we fix your problem?

Windows Update

Troubleshooting report

IsPostback_RC_PendingUpdates

IsPostback: True

Service Status

Problem with BITS service : The requested service has already been started. System.Management.Automation.RemoteException More help is available by typing NET HELPMSG 2182. System.Management.Automation.RemoteException

Service Status

Problem with BITS service : The requested service has already been started. System.Management.Automation.RemoteException More help is available by typing NET HELPMSG 2182. System.Management.Automation.RemoteException

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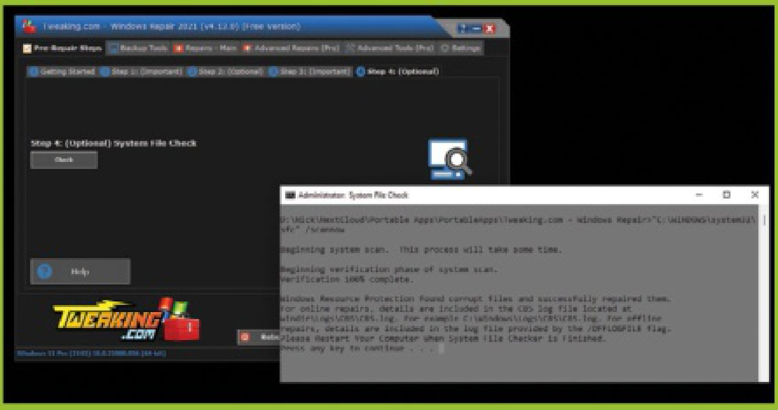
» When the troubleshooter finishes, it will provide a summary of what, if anything, it has discovered and tell you if it has attempted fixes. It's rather vague, so click 'View detailed information' to view the report in full. The dialog's a little small, so scroll down and click 'Detection details' next to 'Issues found' where you may see additional information [**Image F**] that, if the troubleshooter fails to fix your problem, can be added to your web search for possible help.

» You don't need to wait for Windows to prompt you to run a troubleshooter—open Settings and navigate to System → Troubleshoot where you'll be able to change Windows' behavior regarding recommending troubleshooters. More crucially, you'll also be able to access a list of troubleshooters by clicking 'Other trouble-shooters'. The dirty secret is that this isn't a comprehensive list—type 'troubleshoot' into the 'Find a setting' box and you'll uncover others, such as compatibility troubleshooters for older programs and Windows Firewall. ⏻

TEST AND REPAIR



```
Beginning system scan.  This process will take some time.

Beginning verification phase of system scan.
Verification 100% complete.

Windows Resource Protection found corrupt files and successfully repaired them.
For online repairs, details are included in the CBS log file located at
windir\Logs\CBS\CBS.log. For example C:\Windows\Logs\CBS\CBS.log. For offline
repairs, details are included in the log file provided by the /OFFLOGFILE flag.
Please Restart Your Computer When System File Checker is Finished.
Press any key to continue . . .
```

Windows is packed full of tools for testing and repairing different parts of your system but they are a bind to access manually. This is where Tweaking.com Windows Repair Tool Free (www.tweaking.com) comes to the rescue. Once installed or downloaded in portable form to your USB disk, you can run a series of tests and examine its comprehensive set of repair tools that can fix most problems.

The tool is best run in Safe mode—open the program and click 'Reboot to Safe Mode'. Follow the prompts, selecting 'Safe mode with Networking'. Run through the pre-repair steps and if problems are found and fixed, reboot when prompted. If the problem isn't resolved, reboot into Safe mode and run Windows Repair again, this time focusing on its Repairs – Main tab. The tool offers over 30 repairs, with categories such as malware cleanup and permissions only.

Find out more about a repair using the Repair Info tab, then simply tick one or more repairs you'd like to run and click 'Start Repairs'. When they are done, reboot your PC to see whether the repairs have had the desired effect.

Locate and update hard-to-find drivers

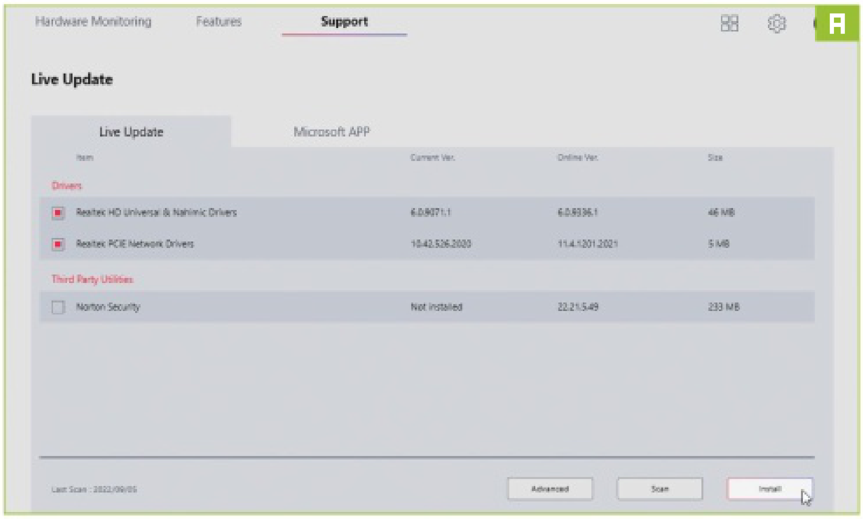
YOU'LL NEED THIS

TRY ONE OR BOTH OF THESE DRIVER UPDATERS

Snappy Driver Installer (free and open source, www.glenn.delahoy.com/snappy-driver-installer-origin/) and IObit Driver Booster Free (adware, www.iobit.com/en/driver-booster.php)

THERE ARE TWO PRINCIPAL REASONS to update your drivers: performance and stability. If you've made do with the drivers installed by Windows, then stability is already a given—these have undergone rigorous tests in the Windows Hardware Quality Labs to earn WHQL certification, signed by Microsoft itself. However, if you're looking for better performance or new features, WHQL-certified drivers aren't always the best option. But where do you track down these newer drivers, and what can you do if you've just installed some new hardware only to discover the supplied drivers don't work or—worse still—don't exist at all?

That's where this tutorial comes in. We'll reveal how to update WHQL-certified drivers and where to find newer ones from your manufacturer, then we'll focus on two tools designed to simplify the process. These driver updaters scan your hardware, identify unknown devices, and locate the newest drivers. Even if you source your drivers directly from your manufacturer, you may not have the latest available ones—driver updaters ensure your PC stays at the cutting edge of driver technology and performance. Here's how it works. **–NICK PEERS**



Item	Current Ver.	Online Ver.	Size
Drivers			
☒ Realtek HD Universal & Nahimic Drivers	6.0.9071.1	6.0.9336.1	46 MB
☒ Realtek PCIE Network Drivers	10.42.526.2020	11.4.1201.2021	5 MB
Third Party Utilities			
☐ Norton Security	Not installed	22.21.5.49	233 MB

Last Scan : 2022/09/05

1 UPDATE THROUGH WINDOWS

The vast majority of your drivers were likely installed with Windows itself, which means they're not only WHQL-certified by Microsoft, but also distributed through Windows Update. If you're looking to check for driver updates for a specific piece of hardware, do so through Device Manager (press Win + R, type devmgmt.msc and hit Enter). Double-click your hardware's entry, switch to the Driver tab, and click 'Update Driver' followed by 'Search automatically for drivers' and finally 'Search for updated drivers on Windows Update'.

›› Alternatively, check all installed WHQL-certified drivers for updates at once: navigate to 'System → Windows Update' and click 'Check for updates' to see if any appear. You can review previous driver updates too—select 'Update history' and scroll down to the 'Driver Updates' section.

2 SWITCH TO MANUFACTURER DRIVERS

WHQL-certified drivers prioritize stability over performance, which is fine for your webcam when video conferencing, but not if you're looking to push your graphics card or chip to the limit. Even when WHQL-certified drivers are updated, they're often behind the curve compared to those available from your manufacturer. If you've bought a desktop or laptop, visit the PC manufacturer's website to see what drivers are available; if you're a self-builder, the mobo manufacturer's website should contain the core drivers you need.

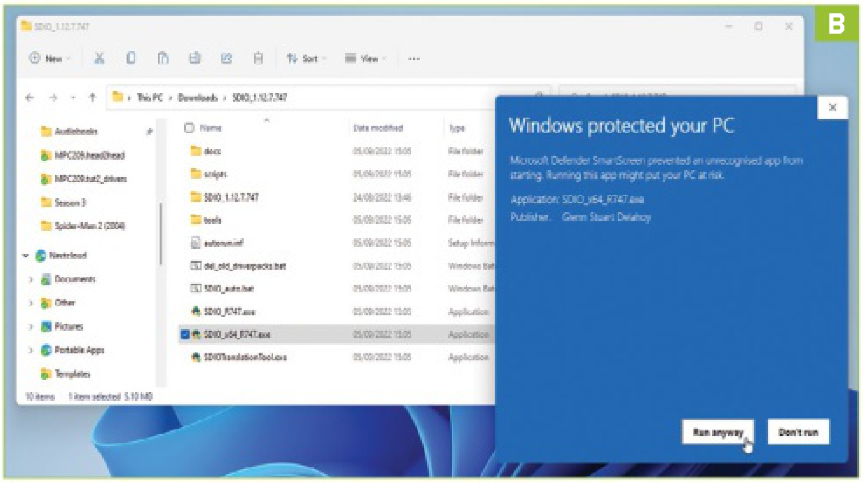
›› Some manufacturers helpfully provide an all-in-one software tool that can be set to run in the background, alerting you when newer drivers have been released across your key components [**Image A**]. This automatic update check is also built into the software installed with NVIDIA and AMD graphics cards.

3 GET THIRD-PARTY HELP

Sometimes you can't track down drivers—maybe the hardware is discontinued, the manufacturer has gone out of business, or it's a cheap unbranded device. The box reveals tools to help you identify specific devices to track down potential drivers or other technical support, but there may be a simpler fix for both this and your desire to keep your drivers updated.

›› The solution is a driver updater tool. There are many available, but only Snappy Driver Installer is open-source, completely free (so no ads), and portable. Go to www.glenn.delahoy.com/snappy-driver-installer-origin/ and click the 'Snappy Driver Installer Origin Version' link to download the tool as a zip file. Extract it to your portable apps folder, then double-click SDIO_x64_R747.exe to run the program.

›› If the SmartScreen filter appears, click 'More info', verify the publisher and click 'Run anyway' [**Image B**]. Some antivirus tools may mistake the program as a virus—simply add an exclusion for the program file.



Windows protected your PC

Microsoft Defender SmartScreen prevented an unrecognised app from starting. Running this app might put your PC at risk.

Application: SDIO_x64_R747.exe
Publisher: Glenn Stuart Delahoy

© MSI, MICROSOFT

4 FIRST RUN

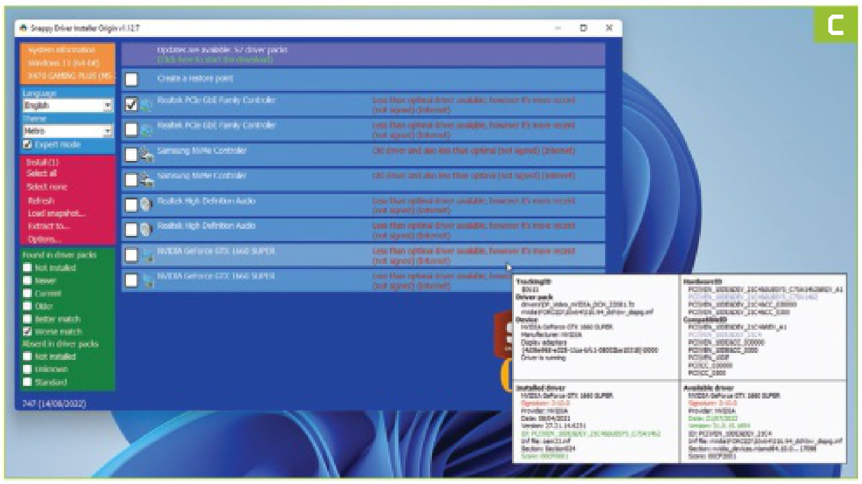
Click Accept followed by 'Allow access' from Windows Defender Firewall if prompted. The welcome screen will ask if you want to download all driver packs, network drivers only, or just the indexes. The latter is the best option, so click 'Download Indexes Only'. On the main screen, a bar at the top will inform you of the index's download progress. Once complete, you'll be told updates are available for the 57 driver packs. Under this, you'll see if any driver updates have been detected.

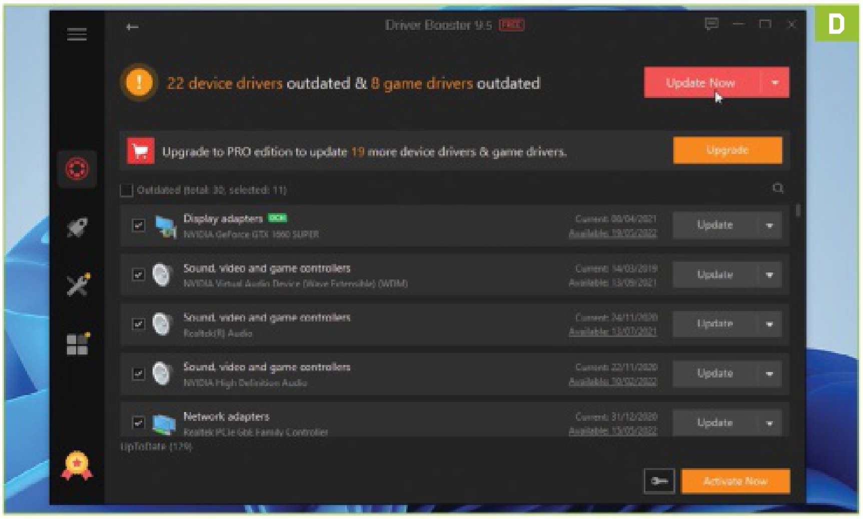
›› You may get lucky and see some recommended updates listed. Check those you wish to install, then click the 'Install' link on the left to download and install the drivers in question.

5 ACCESS EXPERT MODE

If no drivers are found, tick the 'Expert mode' box on the left. A host of new options will appear under 'Found in driver packs'. Check both 'Newer' and 'Worse match' to see a list of drivers appear that closely match your hardware, but aren't considered a better match than the one you have installed. The reason will be listed to the right of the driver, but for more details roll your mouse over the driver and let it hover for a few seconds. A pop-up window will appear providing you with more detailed information—compare the information in the 'Installed driver' and 'Available driver' panes [**Image C**].

›› If you plan to install the driver, be sure to tick 'Create a restore point' first. We also strongly recommend you install these drivers one at a time, to see how your system reacts. But before going down that route, read on...





22 device drivers outdated & 8 game drivers outdated

Upgrade to PRO edition to update 19 more device drivers & game drivers.

Outdated (total: 30, selected: 11)

☑ Display adapters — NVIDIA GeForce GTX 1660 SUPER — Current: 08/04/2021 Available: 19/05/2022

☑ Sound, video and game controllers — NVIDIA Virtual Audio Device (Wave Extensible) (WDM) — Current: 14/03/2019 Available: 13/09/2021

☑ Sound, video and game controllers — Realtek(R) Audio — Current: 24/11/2020 Available: 13/07/2021

☑ Sound, video and game controllers — NVIDIA High Definition Audio — Current: 22/11/2020 Available: 10/02/2022

☑ Network adapters — Realtek PCIe GbE Family Controller — Current: 31/12/2020 Available: 13/05/2022

UpToDate (179)

6 TRY ANOTHER TOOL

Snappy Driver Installer isn't the only free driver updater tool around. If you can live with the ads, IObit Driver Booster Free boasts a catalog of six million drivers. To download the latest free version, go to https://cdn.iobit.com/dl/driver_booster_setup.exe and save the setup file to your hard drive. Untick both boxes under 'IObit Recommendation' before clicking Install. You'll be prompted with other tools during the installation wizard—choose 'No, thanks' before clicking Next.

›› Driver Booster Free is simpler to use than Snappy Driver Installer and offers a wider range of drivers, but you'll have to put up with pop-up ads and nags for its Pro version. After installation completes, untick 'Learn more online' before clicking Scan Now to open the main screen. After the scan completes, a summary screen will list available updates, which you can install one at a time or altogether by clicking 'Update Now' [**Image D**].

›› To find out more about individual updates, click the down arrow and choose Details... to get its version number, publisher, and whether it's WHQL-certified. From here you can apply the update, uninstall the driver, roll back to an earlier version or set it to 'ignore' for this version only or all subsequent updates.

›› You'll find Driver Booster Free is keen to get you to upgrade to the Pro version, but everything you need is available in the free build. ⏻

IDENTIFY PROBLEMATIC HARDWARE

Can't find drivers for a particular piece of hardware? Struggling to identify some hardware? In most cases, either Snappy Driver Installer or Driver Booster Free will detect any unknown devices in your system and provide you with drivers to install. But if you need to know more about a piece of hardware, you'll need the help of a hardware information tool.

Go to Device Manager and you'll see your device listed with an exclamation mark next to it. Double-click and you're likely to have a Code 28 error (drivers not installed). Switch to the Details tab and select the Hardware IDs drop-down menu. Right-click, choose Copy, then paste it into a search engine.

Your search results page should have lots of hits from driver download sites—if you're lucky, you may get a hit that points to a genuine website. For example, we Googled a non-branded TV tuner with the Hardware ID USB\VID_15F4&PID_0131&MI_00 and there was a link to AstroMeta Co in Taiwan (http://www.astrometa.com.tw/integrated_en.html), which hosted the driver we were looking for.

If you're looking for more help identifying hardware, then HWiNFO64 (www.hwinfo.com) can provide you with a detailed description of your CPU, motherboard, and graphics card via a Summary window, while its Sensors window performs a deeper dive. Untick 'Sensors-only' and 'Summary-only' boxes before clicking Start. Use the Sensors window to navigate your system. USB devices can be found under Ports → USB. You'll see all the installed controllers on your system are listed; expanding Root Hub tells you what's attached to it. Select a device and you'll see all kinds of information in the right-hand pane.

From here, you may be able to use the information provided to track down the latest drivers via the manufacturer's website or through a wider Google search for the manufacturer, model, and a combination of keywords, such as 'driver', 'windows 11', and so on.

© SNAPPY DRIVER, DRIVER BOOSTER FREE

Turn a monitor into a digital dashboard

YOU'LL NEED THIS

AN OLD OR CHEAP MONITOR
A monitor wall mount
HDMI and Power Cables
Raspberry Pi 4B or old PC
DAKboard
(www.dakboard.com/site)

HAVING ALL THE INFORMATION you need available on one screen can be a great convenience, especially during the work day. Instead of having to pull up separate apps to check the weather, view your calendar, and read the news, you can have everything in one place.

Sure, there are lots of gadgets out there that purport to do this, most notably the Amazon Echo Show 15, but at around $250, it's a lot more expensive than a standard PC monitor, not to mention significantly smaller. But maybe you have an old monitor around that's not being used, or maybe you've been eyeing an upgrade to something bigger or better. In that case, why not repurpose your old monitor into something brand new, using some free software and cheap hardware? Something that will be of great use to you and your family hanging on the wall of your office, your kitchen, or the entrance of your home?

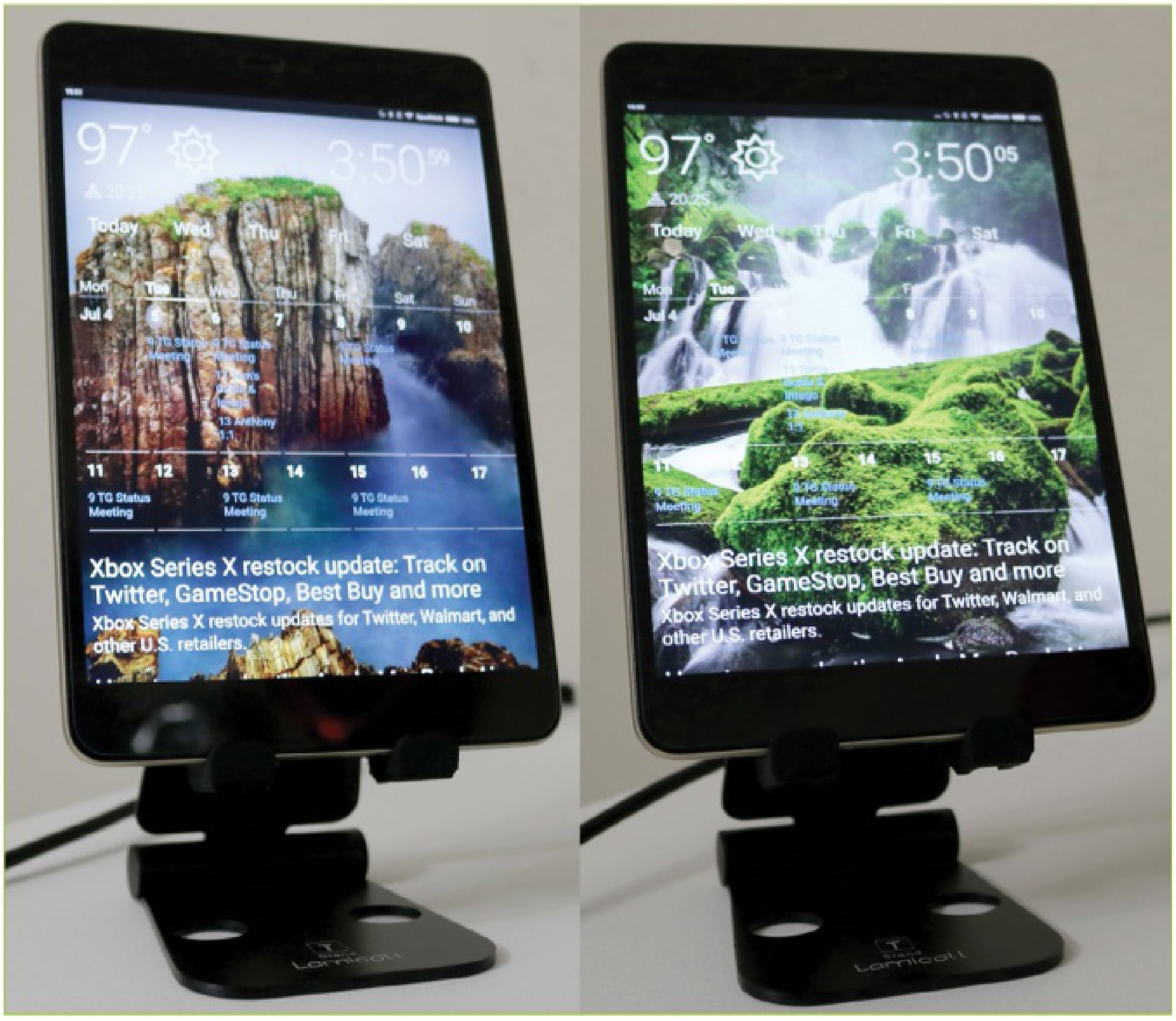
In our example, we used an old monitor and the free DAKboard dash software. We only had to purchase a wall mount and we could put some old hardware to good use. **–ANTHONY SPADAFORA**

1 ROLL YOUR OWN

First launched in beta back in 2015, DAKboard is a customizable web interface used to display photos, calendars, news, weather, and more. Although the company sells a pre-made wall display that has all of the hardware needed (as do certain other third parties), you can also make your own using off-the-shelf hardware.

›› If you don't have an old computer lying around, the cheapest way to do this is to buy a Raspberry Pi 3B+ or a Raspberry Pi 4B, which are recommended by DAKboard. Supply chains are getting better for these cheap micro-computers, but you may still have trouble finding one at their recommended retail prices. Expect to pay around $70 for a Raspberry Pi 4B starter kit with everything you need, including power and HDMI cables, microSD card, and case.

›› As we had plenty of PC equipment around, we decided to use an old mini-PC to get the job done instead. DAKboard supports Windows, in addition to iPads, Android tablets, smart TVs, Amazon Fire TVs, and of course, Raspberry Pi computers. The benefit of using a Raspberry Pi is that it can be tucked behind a monitor pretty easily, and its power draw is much lower than even the smallest of traditional PCs. However, a mini-PC can still be hidden away on a shelf, as we did here.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Xbox Series X restock update: Track on Twitter, GameStop, Best Buy and more
Xbox Series X restock updates for Twitter, Walmart, and other U.S. retailers.

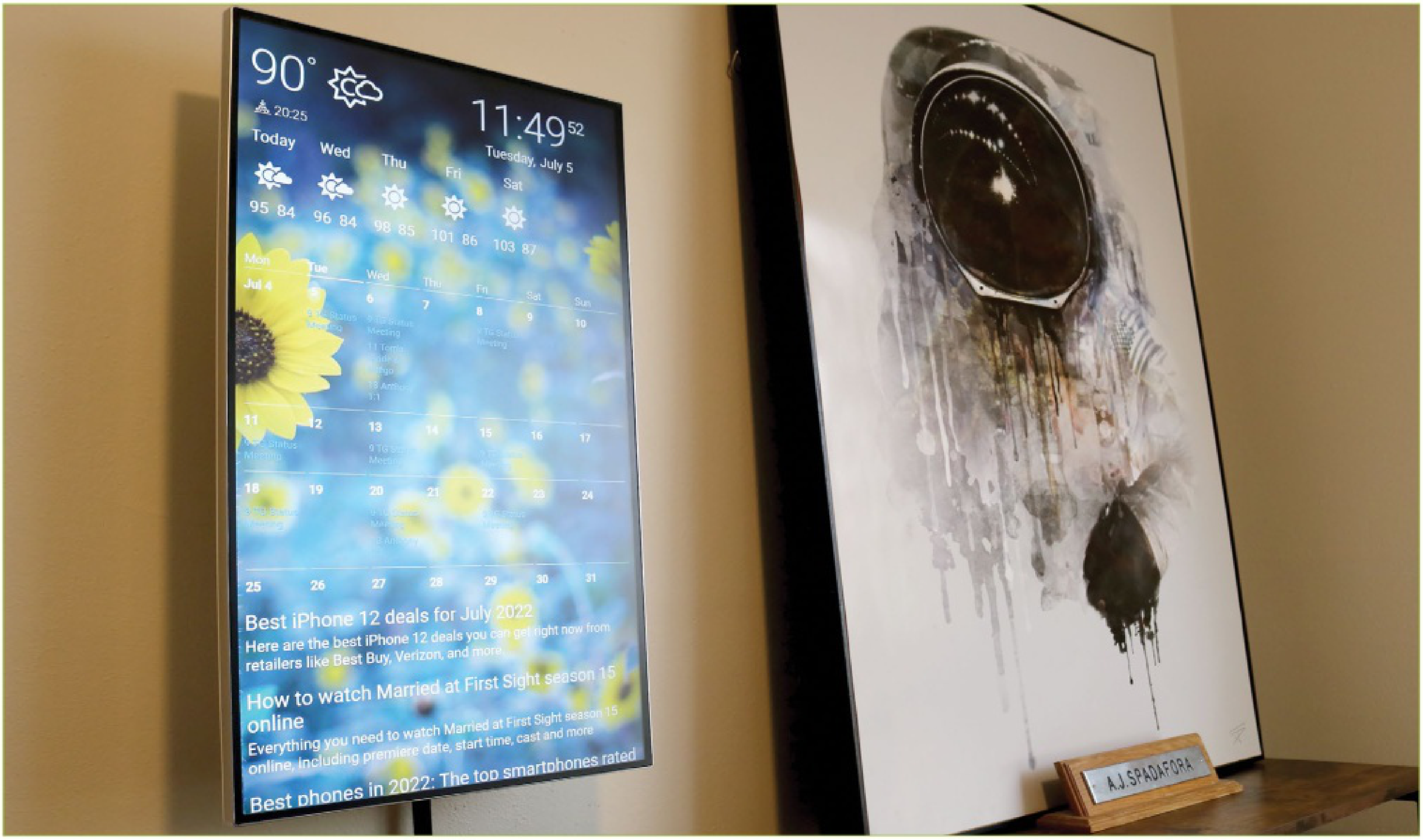
›› **DAKboard's paid plans allow you to run multiple screens in landscape or portrait modes.**

2 PREMIUM CONTENT

Getting DAKboard up and running is a matter of logging into a web interface running in a full-size browser window. The company recommends Chrome, as it tests all the latest features using Google's browser.

›› One of the main reasons we decided to go with DAKboard over something similar, such as Rainmeter, is that we wanted our setup to be easily portable across devices without having to reconfigure things each time. Just bear in mind that if you're using more than one screen, you'll have to pay for one of DAKboard's subscription levels, which start at $5 per month.

›› Another nice thing about DAKboard is its flexibility. Although the free plan limits you to one screen and predefined layouts, the paid plans let you configure multiple screens in either portrait or landscape. We set up both a landscape and portrait screen, though it's easy to switch between the two as each DAKboard (even the free one) has its own private URL. This way, you can add them to your bookmarks and show off your digital dashboard with one click.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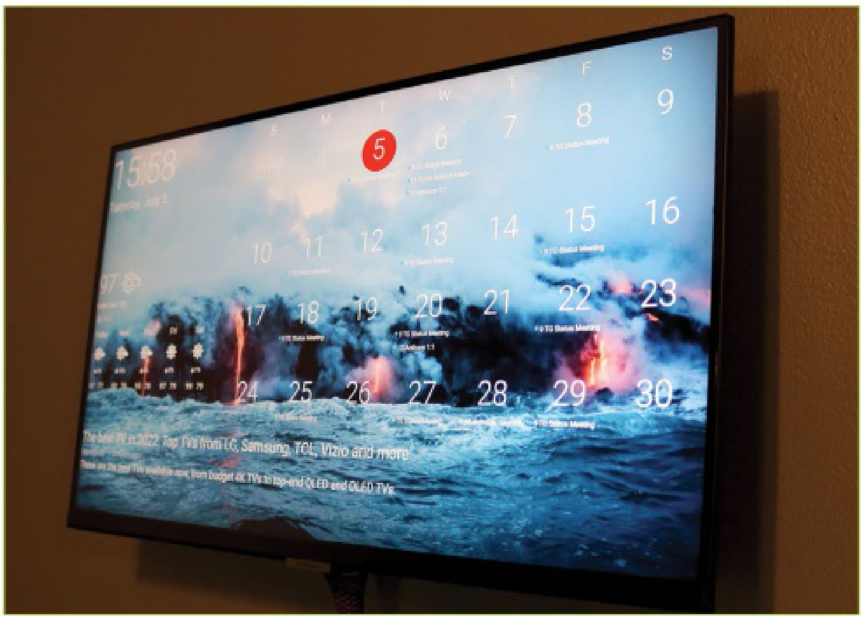
101 86
103 87
Best iPhone 12 deals for July 2022
Here are the best iPhone 12 deals you can get right now from retailers like Best Buy, Verizon, and more
How to watch Married at First Sight season 15 online
Everything you need to watch Married at First Sight season 15 online, including premiere date, start time, cast and more
Best phones in 2022: The top smartphones rated
A.J. SPADAFORA

›› **Landscape or portrait—choose your layout.**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The best TVs in 2022: Top TVs from LG, Samsung, TCL, Vizio and more

3 LEFT TO YOUR OWN DEVICES

We were also pleasantly surprised when testing out a landscape DAKboard, as it automatically scales for larger screens, including an ultrawide monitor. However, we did have to change its resolution manually when trying it out on other devices, such as the Chromebook Duet 3 or an Android tablet.

›› Even with the free plan, you can still make lots of tweaks to the appearance and there are integrations for a variety of photo hosting sites, such as Flickr and Apple Photos, plus you can add your Google Calendar. You can also add an RSS feed showing all the latest stories from your favorite websites, such as our sister publications, *TechRadar* and *Tom's Guide*, where you'll find RSS links at the top of the homepage next to the social icons.

›› If you want more integrations, you'll have to upgrade to a paid plan. That's what we did as we really wanted our digital dashboard to be shown in portrait mode without having to change any settings on the monitor itself.

4 INTEGRATING INTO THE COMMUNITY

Besides giving you more integrations, the cheapest paid plan (Essential, costing $5/month) also unlocks an advanced editor. Those familiar with any of the most common website builders, such as Wix, WordPress, or Squarespace will feel right at home.

›› Much like those website builders, DAKboard's block-based editor allows you to drag and arrange blocks for different tools and integrations to configure your digital dashboard. From stock quotes to Slack messages, there are a wide variety of blocks you can add to your screens so you have all the information you need throughout your day available at a glance.

›› As the Essential plan gives you two custom screens to work with, you could potentially configure one for your work and another for personal matters and switch between the two throughout the day. Likewise, if you have multiple devices, for example, a smart TV and a monitor, you can have both screens on at the same time.

5 DAKBOARD RUNNING ON A TABLET

In our case, we now have a wall-mounted monitor showing a digital dashboard in portrait mode in the home office, plus a repurposed old Android tablet to show calendars and the weather when working elsewhere in the house.

›› Although the digital dashboard has only been up on the home office wall for a few days, it has already been of constant assistance, really helping us to stay on top of things throughout the day.

›› As for the future, we're looking forward to perhaps creating a separate screen with social media feeds to help stay up to date with family and friends. Or possibly one that displays our favorite pictures to remind us of what's most important in life.

LAB NOTES

GUY COCKER, EDITOR-IN-CHIEF

Logitech Creators Day

New keyboards, mice, webcams, and more

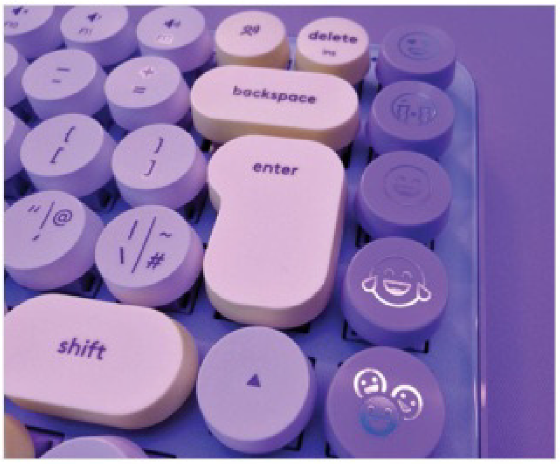
IT TURNS OUT that if you're lucky enough to sit within the Generation Z age bracket, you want a keyboard with dedicated emoji keys, but you don't want to forgo a certain level of quality. That was my takeaway from Logitech's recent Creators Day, where the company showed off its new Pop Keys keyboard, designed to appeal to a younger but still discerning generation.

The wireless keyboard has mechanical keys, just like the excellent Logitech MX Mechanical Mini I covered in my Editor's Pick in the August issue, but unlike that dull office keyboard, the Pop Keys is available in a host of bright colors that Logitech calls 'Daydream', 'Blast' and 'Heartbreaker'.

The Pop Keys also features a host of customizable and swappable emoji keys to the right of the keyboard, so you can emote to your heart's content across emails, iMessages, and Whatsapp texts on your computer or tablet. The Pop Mouse, which comes in the same three colors, is whisper quiet so you don't disturb your roommate, and also features a programmable button to deploy your favorite emoji.

Other learnings from Logitech's press event: the company is getting serious about the high-end streamer market. Its new Blue Sona XLR Microphone and Litra Beam Desktop Key Light bring serious competition to the likes of HyperX in the mic market and Elgato in the lighting department, respectively.

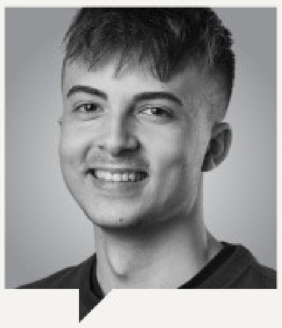
The new gear isn't cheap, with the XLR mic being $350 without the arm to mount it, but has loads of advanced features, such as the ability to zone out key presses and other noises not meant for broadcast. But it oozes quality and feels solidly made—it's set to be a go-to for pro streamers and podcasters alike. The light beam feels better value at $100—it's not as big as the Key Lights from Elgato, but it offers excellent coverage, has a desktop app as well as button controls, and works using USB power, making it more portable and useful on the go.



Logitech's Pop Keys is wireless, mechanical...and has swappable emoji keys.

SAM LEWIS

Staff Writer



I've managed to get my hands on an impressive display recently. Courtesy of Corsair and LG, the Corsair Xeneon Flex 45WQHD240, a 45-inch WQHD resolution display with a 240Hz refresh rate. Oh, and it also bends on command.

I was invited to check it out at Corsair, where I spent around 30 minutes with the display. This involved playing some games on it, which I did terribly—put that down to having an audience observing.

The stats on this screen are impressive, but when you get up close and personal with the screen, it doesn't disappoint. The colors are vibrant without creating an uncomfortable contrast. It's smooth, with a 240Hz refresh rate and fantastic color accuracy, making it ideal for gaming and professional usage.

It's an impressive monitor but its main party piece is its flexibility. That's right! It bends, turning it from a flat ultrawide into a curved ultrawide with multiple angles. This blew my mind when I saw it in action and it's surprisingly less scary to bend a screen than you might think.

There are two handles on each side that you pull toward you, bending the screen in the process. Little clicks occur at each angle of adjustment—I panicked when I first heard it, thinking I'd broken something.

I'm now itching to grab one for myself when they release. It ticks a lot of boxes and has grabbed the attention of the screen tech community.

Editor's Pick: Samsung Odyssey Ark

Throwing a curve ball into the mix

IF YOU'RE into monitors and, let's face it, most PC gamers probably are, then Gamescom was quite the show (read my report on page 50). Corsair showed off what is, to my knowledge, the first manual bendable PC screen in its Xeneon Flex OLED (see Sam's labnote), only to be upstaged by LG's OLED that bends automatically. There was also the Samsung's Odyssey Ark (pictured), a curved display that towers over you in portrait mode, thanks to a 55-inch screen.

The Odyssey Ark is a niche proposition. At $3,500, it costs the same as our high-end blueprint build PC (see page 98) and it's too big for all but the most accommodating of rooms. To paraphrase *Jurassic Park*, it's as if Samsung was so preoccupied with whether or not it could that it didn't stop to think if it should.

For those with the cash and the space to accommodate it though, the Odyssey Ark sets a new benchmark for luxury gaming monitors. It's a full 4K panel, uses Mini LED technology, and supports HDR 10+, 165Hz Refresh Rate, and 1ms response time. It also has four corner speakers and two central woofers with Dolby Atmos support, AMD FreeSync Premium Pro certification, and a gaming hub that lets you play from Xbox Game Pass or GeForce Now without even needing a PC. The only downside is the lack of DisplayPort input, although HDMI 2.1 should be fine for most.

In its widescreen mode, the 55-inch size is comically large, completely filling your peripheral vision when sat at a desk. Still, playing *Tales of Arise* on such an huge display added to the immersion, and the panel's detail, smoothness, and color reproduction were all excellent.

Odyssey Ark

When you turn the screen into portrait, or "Cockpit" Mode as Samsung calls it, things get interesting. This is done by manually rotating the screen, and while it's a smooth motion, it's still a big and heavy (21.1kg) screen. In Cockpit mode, Samsung displayed three different sources at the same time—*Fall Guys* at the bottom, an internet browser in the middle, and an attractive weather widget at the top. Streamers may get the most from this mode—gaming along the bottom, chat in the middle, and stream stats at the top. While the monitor is angled down, you still need to crane your neck to see the top.

The Samsung Odyssey Ark is the ultimate showpiece for the luxury gamer—the kind of person who wants to brag to their PS5-owning friends that their version of Marvel's *Spider-Man* is the best one going. Because it truly will be. You'll need their help to install the 41.5kg screen and its stand, although Samsung is offering free installation with purchase, as well as a free SSD. We doubt anyone with the cash to spare on this thing will need a 1TB Portable SSD, but it's the small things that count. As well as the really, really big things, obviously. **–GC**

$3,500, www.samsung.com

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80 NZXT H7 Flow
82 Backforce V

84 HP Elite Dragonfly G3

87 Mountain Everest Max
88 HyperX DuoCast
89 WD Black SN850X 1TB

90 Rollerdrome
92 Plex vs. Jellyfin

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Intel Arc A380 by Gunnir

This sinking ship needs a better driver

AHOY THERE, mateys! Batten the hatches and prepare to set sail on Intel's Arc, its first proper graphics card in more than two decades. The maiden voyage got off to a rocky start, storms clouded the journey, and the captain seems to have lost his bearings. But can Arc weather the journey, or will all hands go down with the ship while chasing Moby Dick? Yarrrgh!

Enough of the pirate talk. At least the price isn't terrible. If Intel had launched Arc at the beginning of the year, when GPUs were still nearly impossible to come by, it might have stood a chance. Except, even months after the cards first went on sale in China and half a dozen updates later, there are still plenty of driver kinks and issues.

Gunnir's Photon model comes with a 2.45GHz factory overclock instead of Intel's 2.0GHz reference clock. Or rather, Intel lists 2.0GHz as the average game clock; it's not entirely clear how that correlates with Gunnir's boost clock. The card also has a higher 92W power limit, which it hit during testing, so this is about as good as the A380 gets.

The gaming experience ranged from acceptable to problematic. All the games in our test suite worked, though *Minecraft* currently doesn't allow the use of ray tracing—a known issue that will require a game update to whitelist Arc GPUs. There are other games with known problems, and Intel continues to work on the drivers in preparation for the higher end Arc offerings that should arrive in the next couple of months. We also encountered some hardware compatibility issues during our initial testing, some of which have been fixed and others that Intel is still investigating.

Compared with the AMD RX 6400 and Nvidia GTX 1650, the Arc A380 gets the overall performance win. Unfortunately for Intel, neither of those warrants a strong recommendation. Stepping up to a GTX 1650 Super or RX 6500 XT improved performance by 20 percent—without the driver concerns. The GTX 1060 6GB also outperformed the A380 by 10 percent, and the RX 580 8GB delivered 25 percent more performance across our test suite.

There were a few hints of greatness, such as the video encoding hardware. Intel currently has the only GPU with hardware accelerated AV1 encoding, and while AV1 quality at the same bitrate traded blows with HEVC (H.265), its royalty-free nature may win out over time. AMD and Nvidia won't have hardware AV1 encoding until their next generation GPUs launch, and those probably won't trickle down into the budget sector until 2023.

Intel's ray tracing hardware also looks decent. The A380 has just eight RTUs (Ray Tracing Units), but it kept up with the RX 6500 XT's 16 Ray Accelerators. The lack of VRAM on the AMD card was a factor, but the Intel RTUs do have full Bounding Volume Hierarchy (BVH) traversal hardware, including a BVH cache and Thread Sorting Unit that further boosts RT performance. We're certainly interested in seeing how the higher spec Arc A750 and A770 fare in RT workloads.

If you're thinking about buying an Arc GPU, know that Intel lists Resizable BAR support as a requirement, and only 400-series and newer Intel or 500-series and newer AMD chipsets are validated to work. We managed to run the A380 on an older MSI Z390 motherboard (with a few complications), and the A380 performance dropped by 5–20 percent due to the older PCIe 3.0 interface.

We've wondered for some time how Intel's dedicated GPU foray would turn out, and while we're excited to have a third player join the graphics card fray, this is more of a foot in the door for Intel rather than a serious contender. Things may improve over time and the higher-tier GPUs should be much more interesting. Intel is also working on Battlemage, the follow-up to the current Alchemist architecture. The A380, meanwhile, will primarily be of interest to collectors of esoteric hardware, or perhaps people who are enamored with the idea of budget AV1 video encoding. **–JARRED WALTON**

RAM BENCHMARKS

	Arc A380	RX 6400	GTX 1650
Eight-game average (afps)	**58 / 33**	56 / 26	55 / 29
Borderlands 3 (afps)	**71 / 33**	62 / 31	57 / 29
Far Cry 6 (afps)	**62 / 44**	**62** / 29	**62** / 43
Flight Simulator (afps)	42 / 25	42 / 25	**45 / 28**
Forza Horizon 5 (afps)	63 / 23	**66** / 22	64 / **27**
Horizon Zero Dawn (afps)	**64 / 45**	62 / 43	56 / 40
Red Dead Redemption 2 (afps)	64 / **31**	**70** / 26	61 / 30
Total War: Warhammer 3 (afps)	**37 / 19**	26 / 12	33 / 18
Watch Dogs Legion (afps)	61 / **26**	**62** / 22	59 / 20

Best scores are in bold. All testing conducted with a Core i9-12900K, MSI Pro Z690-A WiFi DDR4, 2x 16GB DDR4-3600 CL16, 2TB Crucial P5 Plus M.2 SSD, Cooler Master MWE 1250 Gold V2. Scores are average framerates at 1920x1080 medium/ultra.

VERDICT
4

Intel Arc A380 by Gunnir

+ **NOAH** Great video encoding; 6GB VRAM; DisplayPort 2.0.

− **AHAB** Questionable drivers; spotty gaming performance; broken features.

$139, www.gunnir.cn

SPECIFICATIONS

Architecture	ACM-G11
Lithography	TSMC N6
Boost Clock	2450 MHz
GPU Cores	1024
Memory	6GB 15.5Gbps
TFLOPS FP32	5.0
Bandwidth	186 GBps
TBP	92W
Connectors	3x DisplayPort 2.0, HDMI 2.0

GUNNIR
GUNNIR
INTO THE

Intel's first true dedicated graphics card in 24 years, the Arc A380 is months late and still could have used more time.

An alien? Intergalactic battleship? Cyborg helmet? Nope it's an all-in-one PC.

MSI Aegis Ti5 12th

An OTT design and OTT performance, is this a winning combo for MSI?

AT FIRST GLANCE, you could easily mistake this piece of sci-fi tech as something from Ridley Scott's *Alien*. Looks aside, this all-in-one PC by MSI has plenty of interesting points and has the power below the case to match the crazy chassis. However, with its rather hefty price tag, is this all-in-one worth the extra bucks over a similarly-priced DIY custom machine?

The Aegis Ti5 is a statement piece that could pass as an intergalactic battleship or a cyborg helmet. But while this is clearly a product aimed at gamers, the Ti5's spec sheet is more like that of a productivity PC. So, is MSI limiting its potential market by wrapping a powerful PC up in such an outlandish aesthetic?

Sadly, the overall build quality of this machine is lackluster. At this price, you'd expect a full metal chassis but instead, you get a mainly plastic exterior. The base and handles are made of metal and feel well built and sturdy, and there's plenty of grip. Considering its size, its footprint is relatively small compared with that of a standard mid-tower PC case.

Considering the overall style, the RGB isn't too overpowering and adds a nice subtle glow around the case. One last standout visual feature is a gaming knob at the front of the case. This contains a display that offers a range of functionality controlled from within the MSI Center app. With this handy little dial, you can monitor your PC's performance, adjust media playback, and free up memory. You can also upload your own animations to play on the dial.

The design features different textures, including gloss black areas, a gunmetal gray body, and plenty of mesh grilles for airflow. There are three chambers of cooling within the Aegis Ti5, one each for the GPU, the CPU via a 240mm liquid cooler, and the PSU at the bottom. It runs quietly and, even under heavy load, doesn't sound like it's about to take off.

So, enough about the looks, what's lurking underneath? Lots of power, that's what. Our test model packs an Intel i9-12900K, an MSI GeForce RTX 3090, 128GB of DDR5 RAM, a 2TB SSD, 3TB HDD and supports PCIe 5.0. Prior to the release of AMD AM5 and Intel 13th gen processors, this is as good as it gets.

You get some serious performance here, and it shows in our benchmarking tests. Gaming at 4K on ultra settings offers gameplay from 50fps or higher. At high settings, this rises above 60fps for a smooth 4K experience—that's fairly close to our 4K benchmark gaming machine.

But in the end, the main issue comes down to price. This all-in-one costs nearly $1K more than our custom 4K benchmarking machine. The Aegis Ti5 is certainly an interesting piece of kit and we're sure many people will appreciate the way it looks, but its gaming-inspired design probably won't suit half as many people as a traditional PC case would.

Also, potentially upgrading this machine down the line won't be as easy as it would be in a custom PC. If you want the ease of an all-in-one, the MSI Aegis Ti5 certainly ticks all the right boxes, delivering some impressive performance stats. It's simply a matter of whether or not you will appreciate those rather over-the-top looks. **–SAM LEWIS**

VERDICT 8

MSI Aegis Ti5 12th

+ MONSTROUS MACHINE Excessive power; useful gaming dial; future proof PC.

− MONSTROUS DESIGN Subjective and dividing aesthetic; cheap use of materials; pricey.

$5,199, www.msi.com

BENCHMARKS

	ZERO-POINT	
Cinebench R23 Single-Core (Index)	1,691	1,941 (15%)
Cinebench R23 Multi-Core (Index)	28,692	21,533 (-25%)
CrystalDisk QD32 Sequential Read (MB/s)	7,089	6,950 (-2%)
CrystalDisk QD32 Sequential Write (MB/s)	6,743	5,343 (-21%)
3DMark Fire Strike Ultra (Index)	12,785	12,644 (-1%)
Cyberpunk 2077 (fps)	48	53 (10%)
Cyberpunk 2077 RTX (fps)	23	29 (26%)
Metro Exodus (fps)	77	67 (-13%)
Metro Exodus RTX (fps)	52	45 (-13%)
Total War: Three Kingdoms (fps)	61	56 (-8%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our 4K zero-point consists of an AMD Ryzen 9 5950X, a Zotac Gaming GeForce RTX 3090 AMP Extreme Holo, an MSI MPG X570S Carbon Max WiFi, 32GB of G.Skill TridentZ DDR4-3200, and a 2TB MSI Spatium M480. All games tested at 4K 'Ultra' graphics presets with DLSS/FSR and V-sync turned off. XMP/AMP for RAM speed turned on in all tests. No manual CPU overclocking.

SPECIFICATIONS

CPU	Intel Core i9-12900K
GPU	MSI Geforce RTX 3090
RAM	128GB (4x 32GB) DDR5 4800MHz
Motherboard	MSI Proprietary Z690
Storage	2TB WDC SN810 NVMe SSD, 2.7TB Toshiba DT01ACA300 HDD
Front I/O	USB 3.2 Gen 2 Type-C w/PD, 2x USB 3.2 Gen 1 Type-A, Mic in/ headphone out
Rear I/O	USB 3.2 Gen 2x2 Type-C, 3x USB 3.2 Gen 2 Type-A, 2x USB 2.0, HDMI-out, 3x DP out
Connectivity	WiFi 6E (802.11ax) 2.4Gbps Tri Band 2.4GHz, 5GHz, 6GHz
LAN	2x RJ45 (2.5 + 1GbE) Intel WGI225V + 219V.
OS	Windows 11 Pro
Dimensions	21.69 x 20.12 x 9.41-inches
Weight	33.06lbs

NZXT Canvas 32Q Curved

A fine, but not fantastic, 165Hz gaming panel

© UNSPLASH

NZXT IS A BRAND we know and admire, though not necessarily for its gaming monitors. Better known for cases or even fully-built PCs, NZXT's latest foray into high-performance panels is the Canvas 32Q Curved. With this latest 32-inch, 1440p model, it's clear the brand is getting pretty serious about displays.

Much effort has gone into the design and engineering. The Canvas 32Q Curved has a nicer chassis design and build quality than your average PC monitor and although it is mostly plastic, it looks and feels expensive. The stand adjusts for height, tilt, and swivel but doesn't rotate into portrait mode, which would be problematic for a curved display. That stand is an optional extra, priced at $429 with and $379 without, the extra $50 investment for a stand seems reasonable.

It's all built around a 32-inch, 1500R-curved, 1440p panel. The core panel tech is VA, while the headline refresh rate is 165Hz. Pixel response is rated at 1ms by the more demanding grey-to-grey rather than MPRT metric—that's seriously speedy for a VA panel. We've previously only seen Samsung claim that sort of performance for a VA monitor.

NZXT pegs the peak brightness at a mere 300 nits, while the rated contrast of 1,000:1 is less than expected from a VA monitor. HDR is supported in the form of HDR10 signal processing rather than any true HDR panel capability, of which this monitor essentially has none. There's no local dimming, the peak brightness isn't the stuff of HDR, nor is that contrast ratio.

When it comes to panel fidelity, NZXT doesn't make bold claims, quoting color coverage at 89 percent for the DCI-P3 digital cinema gamut and 99 percent for sRGB. As for inputs, you get HDMI, DisplayPort, and USB-C with DisplayPort alt mode. The full 165Hz refresh is available over the USB-C, but there's no power delivery, so you can't have that sweet single-cable connectivity both driving and charging the display too.

But what of the most critical element, image quality? This is not a monitor that socks it to you from the get-go. There is less contrast than you might expect from a VA monitor and the panel lacks punch. The viewing angles aren't all that, either.

NZXT provides three levels of pixel-accelerating overdrive in the OSD menu. Even the fastest setting is usable, with minimal visible overshoot or inverse ghosting. It isn't as sharp as the best IPS panels but the pixel response will be enough for all but the most demanding eSports addicts, as will the 165Hz refresh.

In-game HDR performance is a washout, and *Cyberpunk 2077* looks little different in HDR mode compared to SDR. What's more, this panel doesn't handle SDR content well when running in HDR mode. So, HDR is generally best avoided unless necessary. Of course, as a 32-inch 1440p display, the pixel density is nothing special. Purely for gaming, that's fine but on the Windows desktop, you won't exactly get crisp fonts.

It may sound as though we have a downer on this display. But while the image quality is more subdued than we'd like, the NZXT Canvas 32Q Curved is quick and responsive, has a well-balanced feature set, and is nicely engineered. It also comes with NZXT's handy CAM app, which allows all the settings to be accessed easily from within Windows. We'd ultimately favor a punchier overall IPS-powered experience, but you might appreciate what NZXT is doing with the Canvas 32Q Curved. –**JEREMY LAIRD**

VERDICT

7

NZXT Canvas 32Q Curved

➕ **FINE WINE** Nice design and engineering; good feature set; decent image quality.

➖ **ANY OLD PLONK** Not a particularly punchy panel; minimal HDR support.

$429, www.nzxt.com

SPECIFICATIONS

Screen size	32-inch
Panel type	VA
Resolution	2,560x1,440
Brightness	300nits
Contrast	1,000:1
Response time	1ms
Refresh rate	165Hz
Color coverage	89% DCI-P3
HDR support	HDR10
Adaptive sync	FreeSync Premium, G-Sync Compatible
Connectivity	DisplayPort 1.2, 2x HDMI 2.0, USB-C

NZXT's 32-inch panel is an unremarkable but accomplished all-rounder

With its perforated front cover, the H7 Flow may be the best of the new range.

NZXT H7 Flow

Is this the pick of the bunch?

NZXT'S LATEST H7 line-up of cases consists of three new models, the H7, the H7 Flow, and the H7 Elite. We've already got our hands on the Elite model, which we reviewed in last month's issue. The Elite was an impressive and handsome chassis and, as the most expensive option, we'd naturally assumed that it would be the best performing choice out of the three.

But while the main focus of the Elite model was its good looks, how does its sibling, the Flow, compare? Costing $70 less than the Elite, is it a better option? At this point, it's worth mentioning that the Flow costs the same as the standard H7 case. Which begs the question, what's the benefit of the standard H7 over the Flow?

Visually, the Flow sits in the middle of the three H7 cases. It's better looking than the standard case with its flat front panel but not as striking as its more expensive sibling, the Elite. However, looks aren't everything. The front panel on our review sample features a matte white perforated cover that allows an unrestricted flow of air through the case. NZXT has executed this well as it not only looks stylish but also allows light from RGB fans to shine through. The clue may be in the name, but this functionality is the H7 Flow's main selling point.

Our review sample is the matte black and matte white version, though separate matte black and matte white offerings are also available. We like the design and the colorway works well on a case with such a minimalistic look, while the contrasting colors add more interest.

Accessing the internals of the case is a breeze. Just like the H7 Elite, the Flow has thumb screws to hold the panels in place. The panels pop off and slide in easily, which is a bonus for those who are planning on making any upgrades or replacing parts in the future. Inside the case, there is more than enough room for either a Mini-ITX, Micro-ITX, ATX, or even an EATX build, so long as the latter motherboard is up to 272mm. This allows for a lot of versatility, making it a great size for most custom PCs.

As well as great compatibility, the H7 Flow features a wide choice of routing options for cable management. Of course, you can pile the cables in, shut the back panel and cross your fingers, but you'll regret it down the line. It's always best to set aside some time to plan your cabling and NZXT does a great job of helping the process with plenty of channels for your wires. There are also Velcro straps to keep everything neat and tidy.

Unlike the H7 Elite, the H7 Flow comes with only two 120mm quiet Airflow fans. Whereas the former comes with three 140mm RGB fans and one 140mm quiet Airflow fan. This may partially explain the price differential between the two cases. The Elite version requires more fans due to its lack of airflow, so it makes sense to charge an extra $70.

Going back to the H7 Flow, the build quality remains high, just as with all the H7 models. Without being too heavy, the case feels rigid and has even panel gaps around it, showing that quality control is important to NZXT. Internally, it features the same clearance and support offered by the standard H7 and the Elite. That's availability for three 120mm fans or three 140mm fans at the front, three 120mm fans or two 140mm fans at the top, and one 120mm or 140mm fan at the back. To help your cooling requirements even further, it's compatible with a 360mm radiator at the top with push-pull, a 360mm radiator at the front, and a 140mm radiator at the rear. Overall, the H7 Flow has some great cooling capabilities.

When it comes to the pricing of the H7 range, it's hard to argue against the Flow being the bargain of the bunch. With the H7 Flow, you get premium styling, a high-quality finish, and versatile functionality. At the same price as the standard H7, it makes you wonder why you'd ever pick that over the Flow model. Unless you really want a super-minimalist case, it's a hard sell.

But on the face of it, it's also a better purchase than the H7 Elite. At $70 cheaper and with an improved airflow giving it a much better cooling performance, the H7 Flow is certainly the most sensible choice out of the new lineup. **–SAM LEWIS**

VERDICT

9

NZXT H7 Flow

⊞ **BEST OF THE BUNCH** Best thermal performance in the lineup; bold color combo; solid build quality.

⊟ **LACKING TOP TIER LOOKS** Not the best looking case in the group.

$130, www.nzxt.com

SPECIFICATIONS

Form factor	Mid-tower
Motherboard support	Mini-ITX, Micro-ATX, ATX, and EATX (Up to 272mm)
Colors	Matte Black, Matte White, White & Black
Window style	Tempered glass
Front I/O ports	USB 3.2 Gen 1 Type-A x2, USB 3.2 Gen 2 Type-C, 3.5mm audio jack
Radiator Support	Front up to 360mm, Top up to 360mm, Rear up to 140mm
Fan Support	Front 3x 120mm/ 3x 140mm. Top 3x 120mm/2x 140mm. Rear 120mm/140mm
Graphic card clearance	400mm
Dimensions	19.8 x 18.9 x 9-inches
Weight	22.15lbs

BACKFORCE
BACKFORCE

In its red and gold color scheme, the Backforce V clearly has the racing look.

Backforce V

High-end gaming chair engineering at a more affordable price

GERMAN CHAIR manufacturer Backforce has made some great gaming chairs for the premium end of the market, such as the $600 Backforce One and the $700 Backforce One Plus. Both chairs were perfect for those all-night gaming sessions, but it was the customization that set them apart, with a wealth of color options, personalized lapels to show off your clan or Gamertag, and adjustable LED lighting on the rear. Not all gamers can afford such luxuries, however, which has inspired Backforce to put its gaming chair know-how into a more budget model, the $400 Backforce V.

One of the big changes to this cheaper chair is that it requires some level of construction, but don't worry, it's not an Ikea-style mission of Allen keys and missing pieces. Though there is an Allen key involved, the building of the chair takes no more than 20 minutes, and the box it comes in acts as a support so you can do it yourself. The wheels, base, stand, arms, and headrest all need to be slotted or screwed together, much like the famed Swedish furniture store's chairs (one of which we were using before the Backforce V).

Our review sample came in red and gold, but there are six other color combinations available, including one based on the League of Legends eSports team Eintracht Spandau. We found our color combination a bold choice, but those who don't like the gamer aesthetic can opt for the Black and White model instead. No matter what color you get, you can customize the shoulder lapels—our review sample said 'Backforce' on one side and 'V' on the other. Further personalization can be made by buying a Pulse LED light for the rear of the chair, although ours didn't come with one.

Other cost-cutting moves include the armrests, which only move up and down, rather than being able to be folded back and out of the way, while the material is fabric, rather than polyurethane leather. You can upgrade to the more versatile 5D armrests at the point of purchase, while Backforce must also get credit for using 100 percent polyester fiber made from recycled PET bottles.

The Backforce V will accommodate most people, thanks to its weight support of up to 130kg and body height support between 151cm and 192cm. The headrest is large enough to support this range, and the shoulder area keeps your back well supported. That said, the chair is narrow at 27cm at the bottom, which initially takes some getting used to if you're coming from a more traditional chair. It appears as though this design choice has been made to support the spine. There's no adjustable lumbar support, however, the chair does an excellent job of maintaining a comfortable pressure if you lean back, while the plastic wheels do a good job of staying stationary as you recline.

There's a handle under the chair to adjust the overall height of the chair by up to 12cm, which is a good amount of travel if you need to fit under a smaller desk. The fabric is also comfortable to the touch, although coming from our Ikea Markus chair (which is popular with gamers on Reddit), we did miss the breathability of its mesh material when sitting in the chair for long work sessions. The padded armrests are much more comfortable on the Backforce, however.

Ultimately, Backforce has done a great job of condensing its gaming chair know-how into a more affordable product with the V. Sure, $400 still isn't that cheap for an office chair (the Ikea Markus is less than half that, for example), but it's a comfortable chair with great customization options and excellent green credentials. **–GUY COCKER**

VERDICT
7

Backforce V

⊞ **V FOR VICTORY** Supports range of body heights and weights; recycled materials; customization options.

⊟ **V FOR VENDETTA** Armrests don't fold away; polyester material can feel hot; RGB lighting costs extra

$400, www.backforce.gg

SPECIFICATIONS

Materials	Plastic, Aluminum, Recycled PET Polyester Fabric
Recommended body height	151-192cm (4ft 9in-6ft 3in)
Tested body weights	45-130kg (100-300lbs)
Total height with base	127cm to 139cm
Height of seat with base	45cm to 57cm
Height of backrest	82cm
Warranty	10 years

The Dragonfly's sleek chassis is hiding some fairly serious flaws.

HP Elite Dragonfly G3

Epic battery life, but otherwise a bit borked

IT'S NOT OFTEN that a product from one of the biggest brands in computing genuinely disappoints. But without giving away too much too soon, there's no getting around it—the HP Elite Dragonfly G3 is a bit borked. Part of the problem is its pricing. With a base price near $2,000, and our review unit coming in well over that figure, this 13.5-inch premium ultraportable should be just about perfect. That's especially true when you consider that Dell's gorgeous XPS 13 Plus starts at $1,299. But even for the same money, there would still be lots to lament about this laptop.

We wouldn't be complaining about the build quality. OK, the chassis design looks dated compared to that uber sleek Dell. But for an ultra-portable measuring just 16mm thick, the aluminum and magnesium frame feels sturdy. Likewise, the keyboard bed is nice and solid. Only Apple does that better in a thin and light laptop with its rock-solid M1 Air. With the new M2 Air losing some of that stiffness, the HP is at least on a par, looking and feeling like a proper premium laptop.

HP has also done a nice job with connectivity. You get a pair of full Thunderbolt 4-spec USB-C ports, one on either side of the chassis. However, the clever bit is the USB-A port, enabled in such a slim chassis by a hinged flap. HP has also crammed in a full-size HDMI socket. The remit here is productivity and those full-sized ports will be welcome for getting serious work done.

We also like the 3:2 rather than 16:9 or even 16:10 screen format. On smaller screens such as this, having that little bit of extra vertical space—in this case, 1,920x1,280 pixels instead of 1,920x1,080—is particularly handy. What we don't like, and this is where the issues really kick in, are the truly awful viewing angles. Even viewing the 13.5-inch panel from dead on, you can see a visible vertical delta in colors and contrast.

HP does offer an optional 3,000x2,000 pixel OLED panel, which on this viewing we think is probably essential. But it shouldn't be necessary to upgrade just to get decent viewing angles on such an expensive laptop. The other obvious problem is performance. By the benchmarks, the Dragonfly does fine. The Intel 12th gen CPU is a low-power U-series model with two performance cores and eight efficiency cores. And it puts out decent numbers.

The SSD is adequate too, even if it's a fairly low spec WD PCIe 3.0 drive with sub-1GB/s write speeds. Ditto the 16GB of RAM. That's plenty for this class of laptop. But there's something about the detailed setup of this system that hasn't worked out. During software installs, it's appallingly laggy, beyond anything that you could blame on a slightly elderly SSD.

The Dragonfly is also slow loading up any data-heavy apps. Not that you're realistically going to be gaming on this laptop—that isn't what it's designed for and we wouldn't expect it to be any good at gaming—but game level loads take an eternity.

It's a pity, because this laptop ought to have so much going for it. That includes excellent battery life. We extracted over 14 hours of 1080p video playback. In other words, this system will deliver true all-day, mains-free operation. We also like the fact that the powerful 100W charger is compact, making the whole ensemble portable. It could have been a fabulous laptop, the HP Elite Dragonfly G3, with its nifty 3:2 factor, mega battery life, and slick build. But it's just too flawed at any price, let alone the lofty positioning HP is attempting, for even a qualified recommendation. **–JEREMY LAIRD**

VERDICT **5**

HP Elite Dragonfly G3

+ HOUSE OF THE DRAGON Lovely build quality; fantastic battery life.

– HOUSE OF CARDS Screen has terrible viewing angles; performance can be especially laggy.

$2,112, www.hp.com

BENCHMARKS

	ZERO-POINT	
Cinebench R23t (pts)	10,986	6,992 (-36%)
3DMark: Firestrike (pts)	11,430	4,560 (-60%)
PCMark 10 (pts)	6,310	5,343 (-15%)
Metro Exodus (fps)	37	10 (-73%)
Total War: Three Kingdoms (fps)	38	20 (-47%)
Crystal Disk read (MB/s)	3,550	2,487 (-30%)
Crystal Disk write (MB/s)	3,224	1,850 (-43%)
Crystal Disk 4K read (MB/s)	73	57 (-22%)
Crystal Disk 4K write (MB/s)	172	155 (-10%)
4K x265 encode (fps)	6.9	5.5 (-20%)
Battery life (1080p video playback)	11h 47m	14h 4m (+19%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point is the Dell Inspiron 16 Plus, consisting of an Intel Core i7-11800H, Nvidia GeForce RTX 3050, 16GB DDR4 RAM, and 512GB NVMe SSD. All game tests were performed at 1080p at the highest graphical profile.

SPECIFICATIONS

CPU	Intel Core i7-1255U
Graphics	Intel Iris Xe integrated
RAM	16GB DDR5
Screen	13.5-inch, 1,920x1,280, IPS
Storage	512GB, PCIe Gen 3
Ports	2x USB4 / Thunderbolt 40Gbps, USB-A 5Gbps, headphone, HDMI 2.0
Connectivity	Wi-Fi 6E AX211 (2x2), Bluetooth 5.2
Camera	5MP webcam
Weight	2.2lbs
Size	11.7 x 8.67 x 0.64-inches

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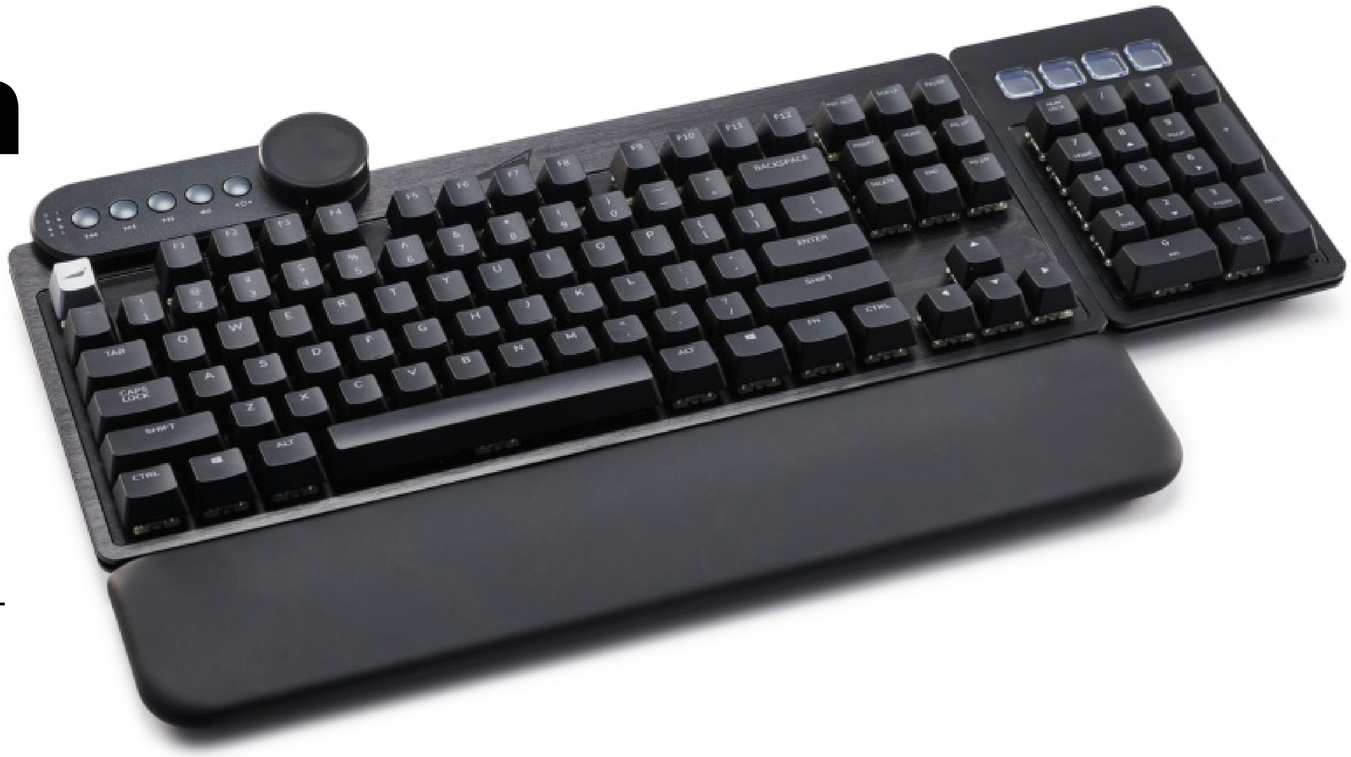
Mountain Everest Max



This keyboard does it all—and has plenty of customization

HAVE YOU EVER looked at your keyboard and thought, 'I really wish it felt a bit more like something out of *Dexter's Laboratory*?' No? Well, you will be after reading this review, because that's exactly how using the Mountain Everest Max keyboard feels.

The Everest Max is the Batman utility belt of keyboards. It comes with a media dock, numpad, and wrist rest, all of which are detachable and (in the case of the former two) can be placed on either side of the keyboard. Every part of it feels like it has its primary use and then some other secret use because its inventors are so darned clever. Even its shipping box has a drawer with cute little compartments for all the pieces.

Many keyboards come with media docks but few are as interesting as the Everest Max's. For one thing, it can be placed on the left or right of your keyboard. There are several media keys to control Spotify and the like, but the most intriguing part is the dial. It has a built-in display, but unlike some rivals with gimmicky GIF displays, Mountain's screen works as a menu, letting you change the dial's functions on the fly. You can see your PC's usage stats, choose from an array of equally distracting RGB effects, or even learn your average gaming APM for a dose of pride (or shame). The only thing missing from the media dock is a volume roller, which makes turning down that unexpectedly loud track on your headphones a little more laborious.

The numpad continues the customization theme, as it comes with four buttons that can be assigned anything from keyboard macros and app-specific shortcuts to launching programs and deeper Windows commands. And with OBS Studio integration, it even becomes a miniature Stream Deck.

FEATURES LARGE AND SMALL

Our review unit came loaded with Cherry MX Blue keys with pre-lubed Cherry stabilizers, and being the keyboard warrior that we are, these felt perfect for bashing our latest Twitter missive out into the ether. Mountain lets you choose from Cherry MX Blue, Red, Brown, Silent Red, and Speed Silver switches. But it's no problem if you later change your mind, as every key is hot-swappable by default. Swapping them out is easy too, thanks to the included key puller. Mountain even includes a sample of each switch it offers so you can make up your mind.

But it's not just the large, headline features that make this a standout keyboard, the little things add up too. There's a two-meter braided USB cable so thick it could be reasonably described as 'swole'. The underside of the Everest Max has multiple built-in cut-outs to angle the USB cable however you like. And, like a grimly determined parent weathering their child's latest tantrum, the magnetic wrist rest is firm without being overly hard.

There are stackable magnetic feet so you can adjust the tilt angle of the board; although the Everest Max came with eight, that wasn't enough to get the keyboard to the height we wanted and have enough spare for the numpad too. It's only a minor setback, though.

Everything is tied together by the Base Camp app, which houses a smorgasbord of customization options. Want to change the exact speed, brightness, and direction of your intricate RGB lighting? Of course you do, and you can in Base Camp. Feel like creating a macro setup so you never need to use your mouse again? That's doable. There are game mode tweaks, key binding adjustments, profile management tools, and options to change the looks and abilities of the media dock's dial. It's pretty comprehensive.

With the Mountain Everest Max, it feels like the design team asked 'how many features can we fit into this keyboard?' to which the answer was 'lots'. If you're prepared to pay, you'll get an incredible keyboard that's fully loaded with almost everything you could need, and then some. **–ALEX BLAKE**

VERDICT
9
KICK ASS!

Mountain Everest Max

+ SUMMIT Everything is customizable; great typing feel; handy media dock dial.

− BASE CAMP Expensive

$259, www.mountain.gg

SPECIFICATIONS

Switch type	3-Pin Cherry MX, hot-swappable
Backlight	RGB
Polling rate	1000Hz/1ms
Keycaps	ABS (PBT Optional)
Onboard memory	Up to 5 profiles
Connector	USB Type-C
Interface	USB 3.2 Gen 1
Media display	RGB TFT IPS 240x204px
Warranty	2 years
Dimensions (hwd)	43 x 461 x 265mm
Weight	1373g

HyperX DuoCast

HyperX's midrange mic suffers from middle child syndrome

THE HYPERX QUADCAST microphone has to go down as one of the best peripheral debuts of the last few years. HyperX had no pedigree in the market when it launched in 2019, yet seemingly overnight that iconic red mic seemed to be popping up in every gaming-related YouTube video and livestream going. The $160 multicolored QuadCast S arrived the following year, allowing full RGB lighting control, as did the $60 SoloCast option, which was smaller and only had one recording pattern, rather than the QuadCast's four (the clue is in the name).

Which brings us to the $100 DuoCast, which sits in the middle of the existing range, both in terms of price and stature. It looks closest to the SoloCast, given its compact size, but the mic is shaped more like the cylindrical QuadCast. It also has features similar to the QuadCast, such as two polar patterns, a wired headphone port for monitoring, plus a splash of RGB lighting around the center. It also comes with a desktop stand and shock mount, a new USB-C cable, and an internal pop filter to reduce the impact of plosives directed at the microphone.

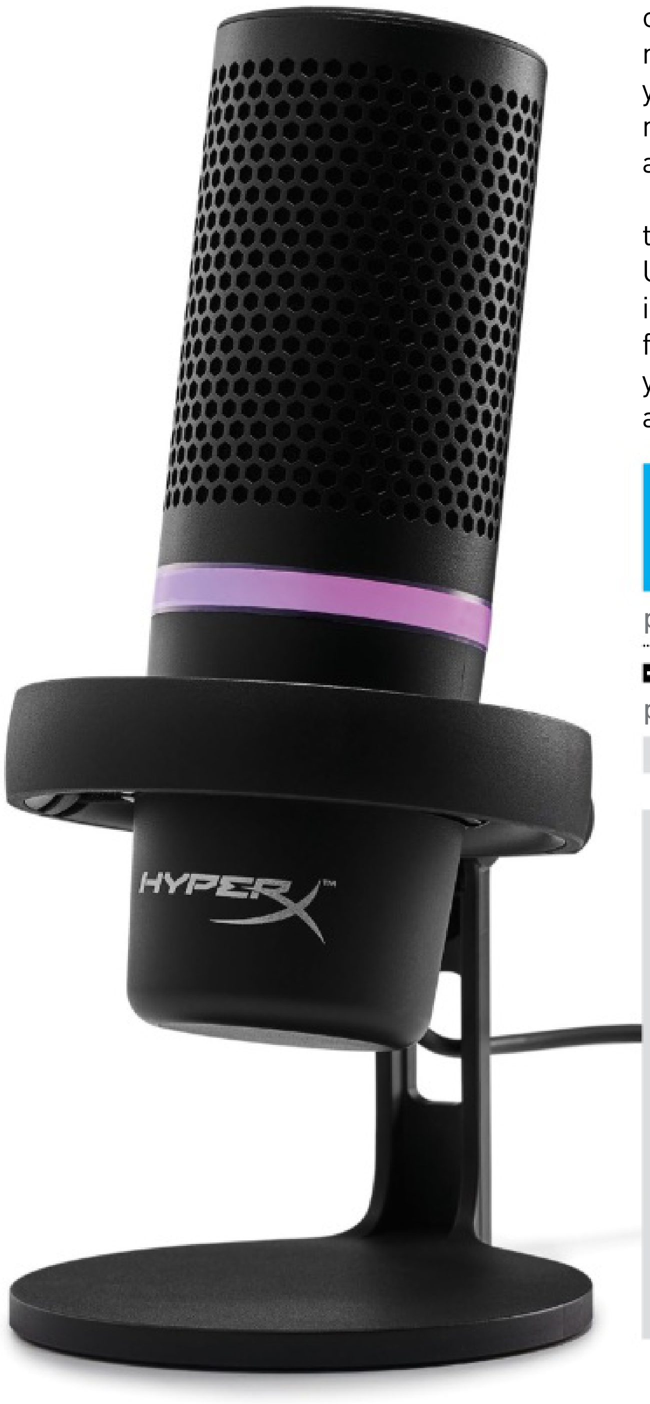
The DuoCast makes a great first impression—it's a luxuriously made microphone that's sturdy without feeling industrial, and full of thoughtful design touches while still being easy to use. The mic comes pre-mounted in its own stand, but there's a mount adapter in the box if you're going to be attaching it to an arm. There's also a 2m USB-A to USB-C cable in the box—that's long enough for most but, ideally, it could have done with a longer cable (you can just buy or bring your own).

POSITIVE VIBES

The positive vibes continue when you plug it in and try it out. This will make an excellent comms device whether you're talking to squadmates, recording a podcast, or just on a work call. The 24-bit/96kHz recording does an excellent job of capturing clear vocals thanks to its high bit depth and sampling rate, and we couldn't detect any difference between this and the original QuadCast in terms of recording quality.

The two polar patterns, cardioid and omnidirectional, will be enough for most people to either record themselves or a conversation with other people. The caveat is that you lose some clarity when using the latter—it's better used for capturing a conversation, rather than for professional podcasting. That said, it will be enough recording options for most people. You're only missing the stereo and bi-directional modes from the QuadCast, which many won't need.

The DuoCast boasts loads of thoughtful design elements that make it a joy to use. The stand lifts the microphone just high enough to clear a standard keyboard, but the mic is petite enough to stay underneath a standard monitor, making it a real space saver on a desk. The volume knob on the back doubles as a button to change recording modes, while the mute button on top is easily accessible and the RGB light turns red to let you know when you're muted.



The problem comes with the price of the DuoCast. At $100, it's cheaper than the $160 QuadCast S, but that product is frequently on sale at around $120, and we think it's worth snapping up for an extra $20. Or take the standard QuadCast, which was on sale for $90 at the time of writing on HyperX's website—$10 cheaper than the DuoCast. Again, you might not need the extra features, but you'd be better off saving some money now and having more recording options available down the road if you need them.

The DuoCast is a great microphone for those who need an easy-to-use, quality USB offering, but it needs to come down in price to be a recommended purchase from us. Though the QuadCast is three years older, it is currently a better option at $90. **–GUY COCKER**

VERDICT

7

HyperX DuoCast

+ **DOUBLE DRAGON** Great build quality; excellent sound; plenty of features.

− **DOUBLE TROUBLE** Too close to QuadCast price; only comes in black.

$100, www.hyperx.com

SPECIFICATIONS

Lighting	RGB (16,777,216 colors, 2-zones)
Bit-depth	24-bit
Connection type	USB-C (2.0), 3.5mm headphone output
Frequency response	20Hz-20kHz
Polar pattern	Cardioid, omnidirectional
Power consumption	5V 200mA (white light)
Weight	0.53lb (0.24kg)

WD Black SN850X 1TB

WD gives its top SSD some added X-factor

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WD'S BLACK SN850 was one of our favorite PCIe Gen 4 drives. So, this new SN850X model is certainly intriguing. What it's not, to be clear, is a fancy new PCIe Gen 5 drive. If that's disappointing, the reality is that there's barely any support for PCIe 5 storage right now. Yes, Intel's Alder Lake CPU family has limited PCIe 5 support, it doesn't have dedicated lanes for storage, so it all gets a bit complicated. Meanwhile, AMD's new Ryzen 7000 chips have proper PCIe 5 storage support, but they have only just been announced.

With that PCIe 5 digression dealt with, what to make of this SSD, likely one of the last of the high-end PCIe 4 generation? As before, it's a quad-lane PCIe Gen 4 M.2 drive, this time with an updated version of WD's in-house controller chip, albeit there are no details on exactly how the new controller has been improved.

The new 'X' model reviewed here starts at 1TB and goes all the way to 4TB. The old non-X kicked off at 512GB and topped out at 2TB. The drive's NAND flash chips have been upgraded from 96-layer TLC chips to newer 112-layer items. WD isn't quoting specific improvements from the chips, but typically new-gen NAND flash improves on throughput and latency.

Comparing this 1TB model with its direct progenitor, however, overall drive performance is up. Claimed write speeds have edged from 7,000MB/s to 7,300MB/s, while reads leap from 5,300MB/s to 6,300MB/s. As for IOPS performance, the old 1TB drive clocked in at 1M reads and 720K writes. WD has bumped those to 1.1M and 800K respectively.

One thing that doesn't change is write endurance. For this 1TB drive, it's pegged at 600TB, which is the same as both its predecessor and several other drives of the same capacity in this segment, including the Samsung 980 Pro.

For the record, WD is also shipping the latest 2.0 version of its Game Mode drive management software. WD claims it improves game loading times courtesy of a so-called 'read look-ahead' algorithm, which predicts and pre-emptively caches game data. How much that kind of feature makes a difference in the real world is difficult to pin down. But it can't hurt.

Still, we can confirm peak sequential performance has improved more or less in line with expectations. In CrystalDiskMark reads are just over the claimed 7,300MB/s and writes likewise in excess of WD's 6,300MB/s figures. Another upside is improved operating temps. Under load, we measured 58°C peak, down from 77°C for the SN850.

WD says the drive has a new thermal management profile to reduce throttling under load and it seems to work. It's also reviewed here with a full heat sink and the broader aim of this model is to work better in the more challenging thermal confines of a modern game console. No doubt it will deliver on that remit, even if it's not hugely relevant to the PC.

Elsewhere, the gains are more marginal. The overall PCMark 10 storage index edges up from 533 points to 553, while 4K random reads are actually a little lower. That latter drop in measured performance likely reflects the inherent vagaries of measuring SSD performance from one day to the next. There are so many variables. And if you are wondering, WD does not appear to have tweaked the SLC cache provisioning. Sustained performance drops off at the same 300GB mark as the older drive.

Anyway, what we can say overall is that the new WD Black SN850X is not a major leap in performance. We doubt you'd notice any difference in the real world. What it does do, however, is reduce operating temps and that bodes well for long-term performance and reliability. –JEREMY LAIRD

VERDICT
8

WD Black SN850X 1TB

⊞ **UPGRADES'** Runs a lot cooler than before; solid all-round PCIe Gen 4 drive.

⊟ **FAILED THE GRADE** Not really any faster in the real world than the original SN850.

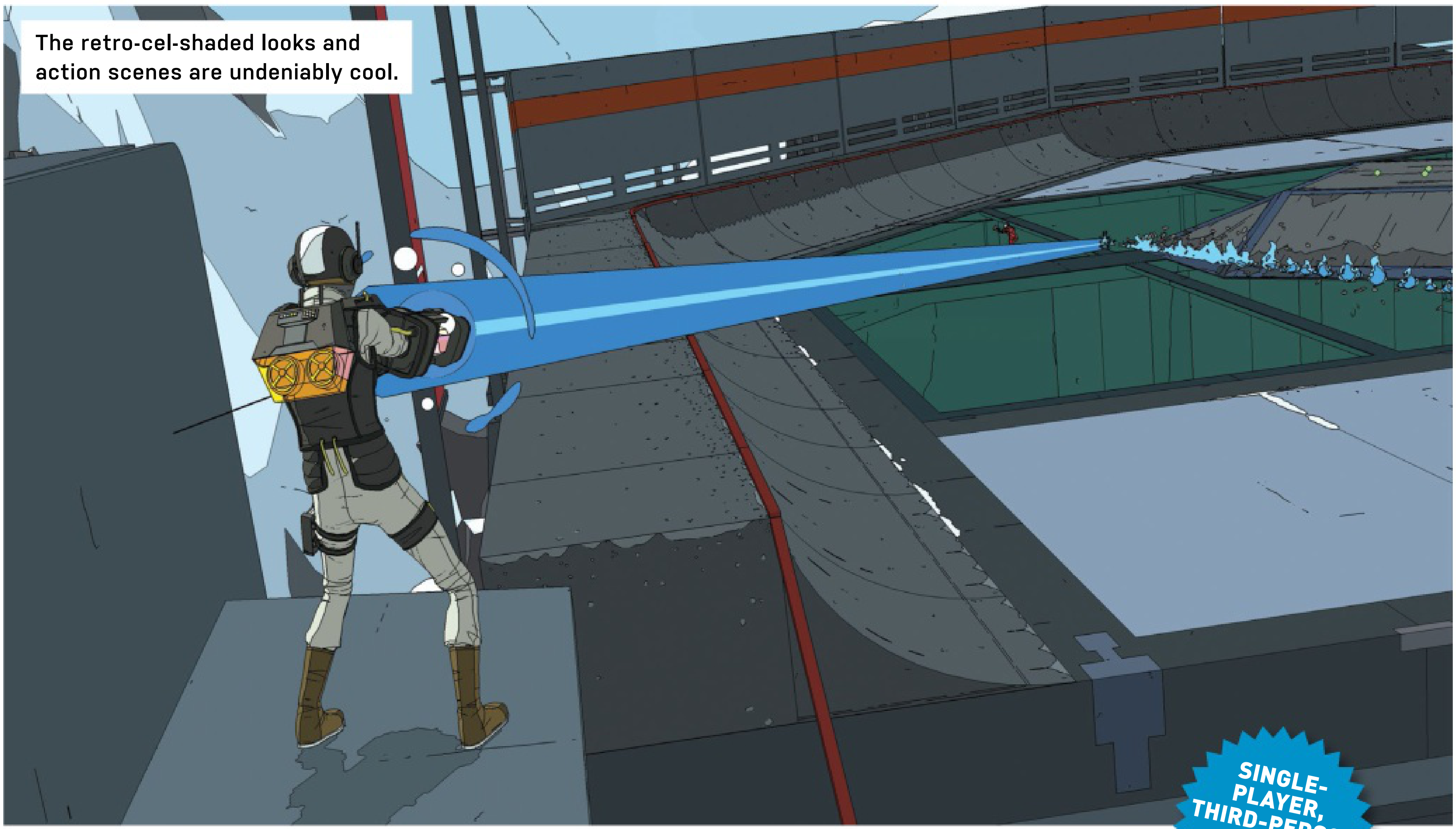
$129, www.westerndigital.com

BENCHMARKS

	WD Black SN850X 1TB	WD Black SN850 1TB
Synthetic performance – ATTO Disk Benchmark Peak Sequential Read (MB/s)	6850	6750
Synthetic performance – ATTO Disk Benchmark Peak Sequential Write (MB/s)	5940	4981
PCMark10 Storage (full) Index	3415	3476
PCMark10 Storage (full) Bandwidth (MB/s)	533	553.14
PCMark10 Storage (full) Average Access Time (μs)	48	48
Peak Temp Temperature (°C)	58	77
CrystalDiskMark 7.0.0 SEQ1M Q8T1 Read (MB/s)	7313	7068
CrystalDiskMark 7.0.0 SEQ1M Q8T1 Write (MB/s)	6374	5233
CrystalDiskMark 7.0.0 RND4k Q1T1 Read (MB/s)	82	90.3
CrystalDiskMark 7.0.0 RND4K Q1T1 Write (MB/s)	238	252

SPECIFICATIONS

Capacity	1TB
Form factor	M.2 2280
Interface	PCIe 4.0 x4
Read/write speed	7300/6300MB/s
Random read/write	1.1M/800K IOPS
DRAM cache	1GB DDR4
SLC cache	300GB dynamic
Write endurance	600TB
Warranty	5 years


The retro-cel-shaded looks and action scenes are undeniably cool.

SINGLE-PLAYER, THIRD-PERSON ACTION SHOOTER

Rollerdrome

Everything's more fun on roller skates

SOME GAMES are defined by their graphics, some by their plots, and others by their dialog choices. However, there's also a more nebulous category of games that are defined by their feel, and Rollerdrome is most definitely one of those.

How does it feel? Cool. Outrageously so. It involves roller skates, and its main influences seem to be *The Running Man* (1987) and *Rollerball* (1975), which are so likely to be lost on anyone under 30 as to perhaps be new and fresh.

The plot is that you are the newest recruit to a near-future, arena-based bloodsport by the name of Rollerdrome, in which challengers take on (and shoot) the 'house players'—all manner of out-of-work professional wrestlers and *Mad Max* extras armed with spiky clubs, armor, sniper rifles, and rocket launchers. For reasons left completely opaque, but probably to do with speed, fluidity of movement, and traversal, they're expected to do this on roller skates.

This means you can do tricks, something which is encouraged both by the layout of the arenas and the scoring system. Grinding on rails and the edges of the arena is the only way to reload your gun (we're not sure how this works but in the heat of the moment it's best to just go with it) while you rack up points by pulling off a variety of grabs and flips while airborne, especially in designated areas where the cameras can get a good look at you. If you can do this while shooting somebody in the head, all the better.

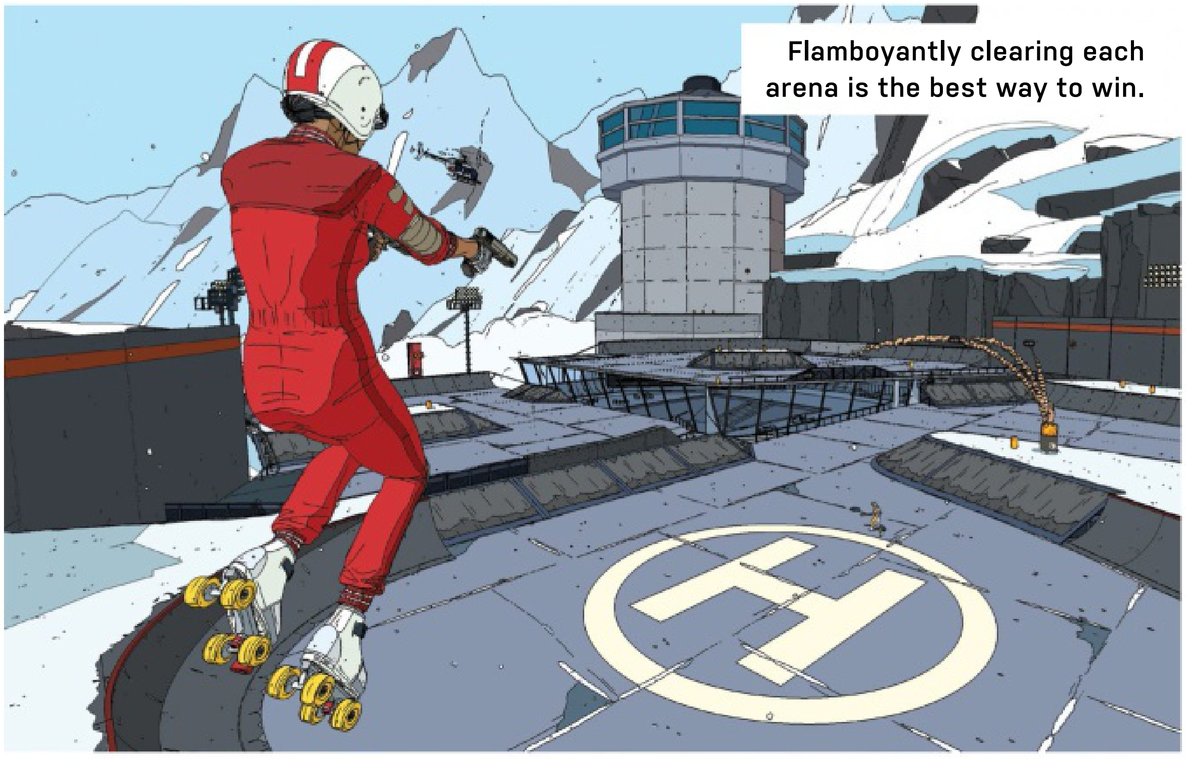
Clearing each arena flamboyantly is the way to win. Killing goons, who constantly respawn until you've hit a target number, tops up your health, but even better is to avoid getting hit at all. A dodge move is tightly bound into the game, allowing you to duck under incoming weapons. Thanks to a strange flaw in the snipers' laser sights that makes the beam flash from red to gray, you can also roll out of the way of bullets. Dodging them gets you more points, as does pulling off tricks and kills. At the end of the match, you are graded on your tricks and kills, your performance held up against your personal best, and that of the reigning champion.

You have one other advantage to help you survive the onslaught—the ability to slow down time, a simple pull of the left trigger putting you into a Max Payne-like state no matter what you're doing, whether you're upside down in the middle of a trick, or just rolling across the arena in an attempt to pick up speed. Aiming is automatic, as long as your intended target is roughly somewhere you can hit, as is forward motion once you've got started (though it's really hard not to push the stick forward anyway, there's nothing like 20 years of muscle memory to force you into a redundant action).

Motion is utterly fluid, as you might expect from the studio behind the *OlliOlli* skating games, and the general feeling is that perhaps *Tony Hawk* wasn't exciting enough, so someone decided to add guns to his world. Replayability is high, as you're encouraged to play arenas over and over to increase your score once you've cracked surviving them, with pickups and targets to hit around the arena, sometimes added in by helicopter while the match is underway.

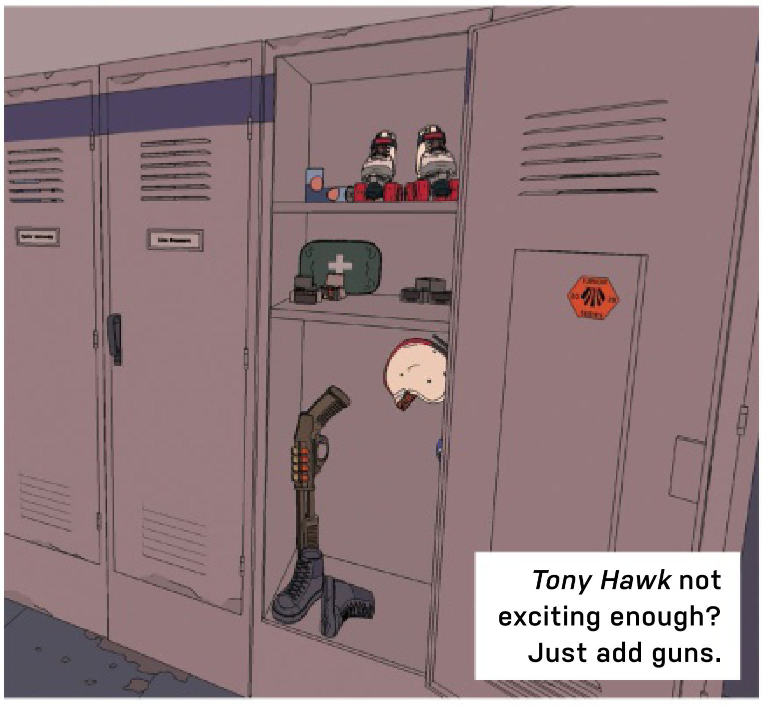
The background to the near-future roller-slaughter is as keenly designed as the cel-shaded aesthetic of the game itself. You're paying to enter these games, racking up a ruinous debt to the company, Matterhorn, that runs the championship in the process. It develops into an uncomfortable relationship between Matterhorn's weapons development, the Rollerdrome, and law enforcement, and blossoms as you pick up hints about what's really going on, and whether you'll ever be allowed to leave, even if you win.

© PRIVATE DIVISION, TAKE-TWO INTERACTIVE

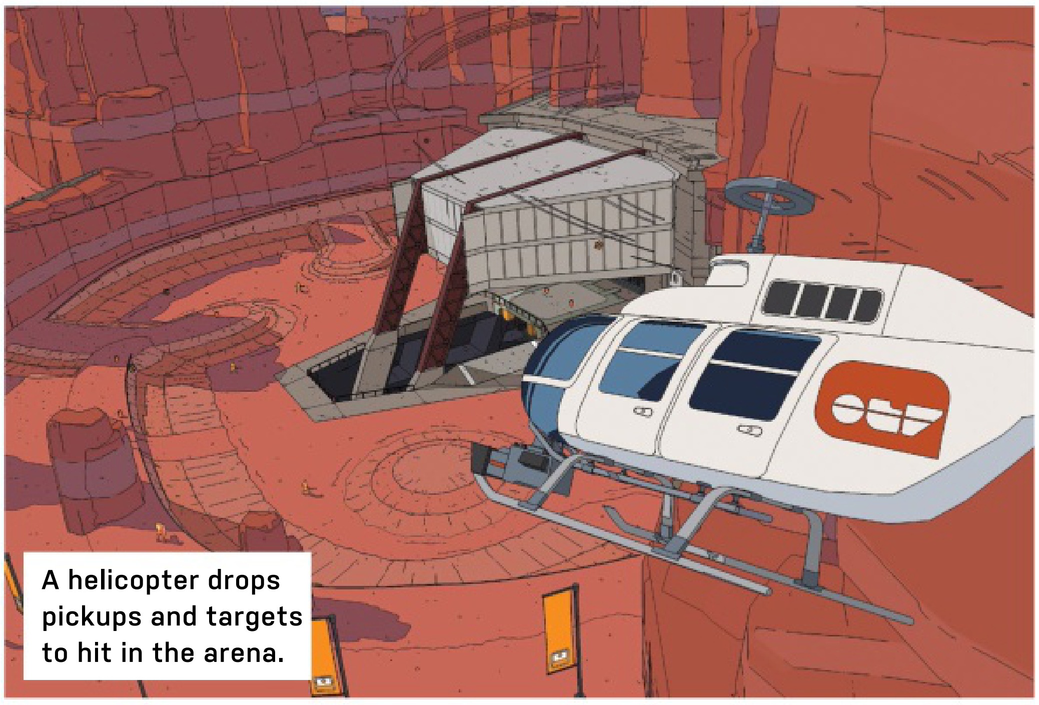


Flamboyantly clearing each arena is the best way to win.

Defeat rivals with tricks including slowing down time.



Tony Hawk not exciting enough? Just add guns.



A helicopter drops pickups and targets to hit in the arena.

Given what you discover, you should feel exceptionally guilty about the slow-mo bullets you pump into house players while hanging upside down in mid-air, but this is impossible. Playing *Rollerdrome* is such a blast, such a direct shot to the pleasure centers of the brain, that questions of morality pale alongside the prospect of more time spent wall-running with a shotgun.

SIMPLE INGREDIENTS

There aren't many weapons, only a limited number of environments to use them in, and there aren't many things to do, but the game spins so much cloth out of its simple ingredients—roll, shoot, jump, trick, dodge, and slow down time—that it doesn't matter. There's always another approach, always space to skate around and have another go.

One major shock is that this, at the time of writing, is a staunchly single-player game. Online leaderboards are the closest you get to interaction with other players. This seems like a major shortcoming and a multiplayer patch must surely be at some stage of development. One-on-one duels, co-op PVE, and even an entirely new team sport in the spirit of *Speedball* could be born out of this.

Another is the difficulty. The game wants you to spend time perfecting your scores in its arenas, and no jump is so stark as that between the first and second areas. The game has a tutorial, in which you prove your basic competence with the controller and the moves it facilitates, then drops you into the locker room before the first arena. You'll pass this one quite easily with a mediocre score and, bitten by the violent-skating bug, eagerly move on to the next. The difficulty spike is prodigious—suddenly there are snipers and helicopters and guys with rocket launchers. You head back to replay the earlier level, chastened.

The replays, however, are still fun. Merely surviving a level to unlock the next is only the beginning, and there are always more targets to hit, time limits to beat, and additional points to score.

Rollerdrome is an example of a game in which the various systems come together and just work. Its retro-cel-shaded looks are cool, its premise is cool, and its action scenes are cool. The dystopian backstory you pull out of it is also cool, if you thought *Robocop* was cool. Roll7 is onto something huge here, and when you consider that this isn't even a full-priced game and has low specs, that makes it all the more worth playing. **–IAN EVENDEN**

VERDICT 9

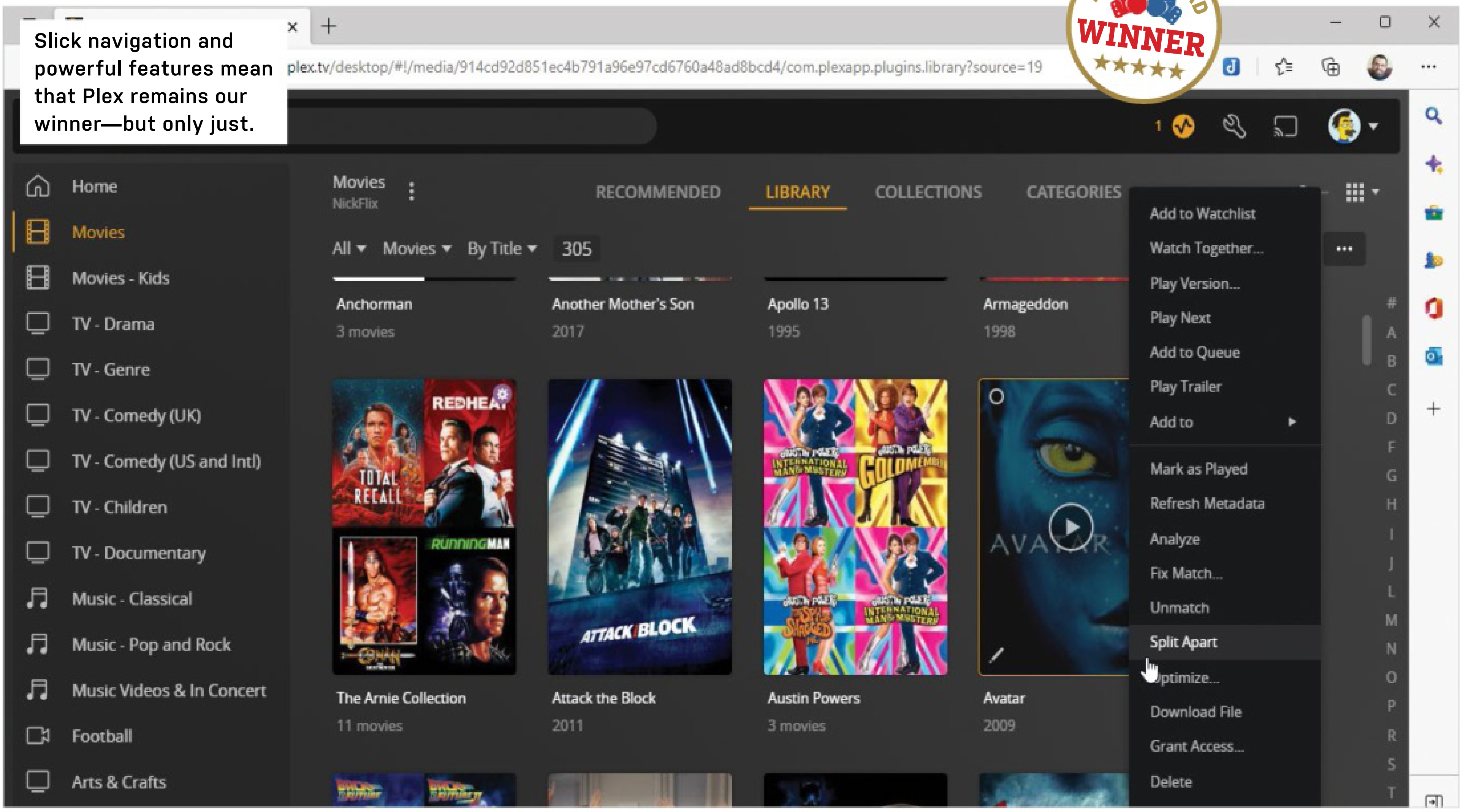
Rollerdrome

SKATE Cool looks; cool game; makes you feel extremely cool.

HATE Difficulty spikes; screaming out for multiplayer mode.

RECOMMENDED SPECS CPU, i3-610 / FX-6300. RAM, 4GB. GPU, GTX 560 Ti (2GB) / R9 270X (4GB) / Radeon Vega 8.

$30, www.rollerdromegame.com, M-rated


plex.tv/desktop/#!/media/914cd92d851ec4b791a96e97cd6760a48ad8bcd4/com.plexapp.plugins.library?source=19
Home
Movies
Movies - Kids
TV - Drama
TV - Genre
TV - Comedy (UK)
TV - Comedy (US and Intl)
TV - Children
TV - Documentary
Music - Classical
Music - Pop and Rock
Music Videos & In Concert
Football
Arts & Crafts
Movies
NickFlix
RECOMMENDED
LIBRARY
COLLECTIONS
CATEGORIES
All
Movies
By Title
305
Anchorman
3 movies
Another Mother's Son
2017
Apollo 13
1995
Armageddon
1998
The Arnie Collection
11 movies
Attack the Block
2011
Austin Powers
3 movies
Avatar
2009
Add to Watchlist
Watch Together...
Play Version...
Play Next
Add to Queue
Play Trailer
Add to
Mark as Played
Refresh Metadata
Analyze
Fix Match...
Unmatch
Split Apart
Optimize...
Download File
Grant Access...
Delete

Slick navigation and powerful features mean that Plex remains our winner—but only just.

HEAD TO HEAD WINNER

Plex vs. Jellyfin

Do you need to pay for a media streaming server?

ONE MEDIA SERVER to rule over them all. That's the dream of anyone hosting a huge collection of media they would like easy access to. For years, that media server has been provided by Plex, a beautifully designed, slick, and powerful tool. While its core functionality is free, there is also a paid-for subscription in which you can unlock extra goodness and features.

However, over the past few years, a young pretender has emerged. Forked from Plex-rival Emby's last open-source implementation, Jellyfin's key commitment is to remain free and open-source for 'now and always'. As we reach its fourth anniversary, now is the perfect time to see how Jellyfin measures up to Plex and which one offers the better overall experience.

When it comes to core functionality, there's little to choose between the two. Both Plex and Jellyfin employ the same server-client model, which delivers your media from a centralized PC, NAS, or server to your various devices on demand. Both apps run beautifully on low-powered hardware, making 24/7 access practical and affordable. Both support a wide range of clients—Plex has the edge, but Jellyfin is closing the gap fast, and also offers both Android and iOS apps for free; Plex users either require a Plex Pass subscription or must pay a standalone fee ($5) for each app.

A key area where Plex and Jellyfin diverge is in how users access the server. Plex requires you to set up a centralized account via Plex's website and connect through that. Configuring your server for remote access and sharing is easier, but there's the question of privacy—one brought into sharp focus by the recent hacking of Plex's servers. You're also forced to route your connection through Plex's online servers even when on the same local network—an 'offline' mode is available when the internet is down, but it's slow to appear.

On the other hand, Jellyfin employs a direct connection to the server, which can be via your local network or over the internet if you have a domain name and reverse proxy. It's rather fiddly to set up, but once done, it works flawlessly. Long story short, if privacy is your thing, Jellyfin's model is the one to go for.

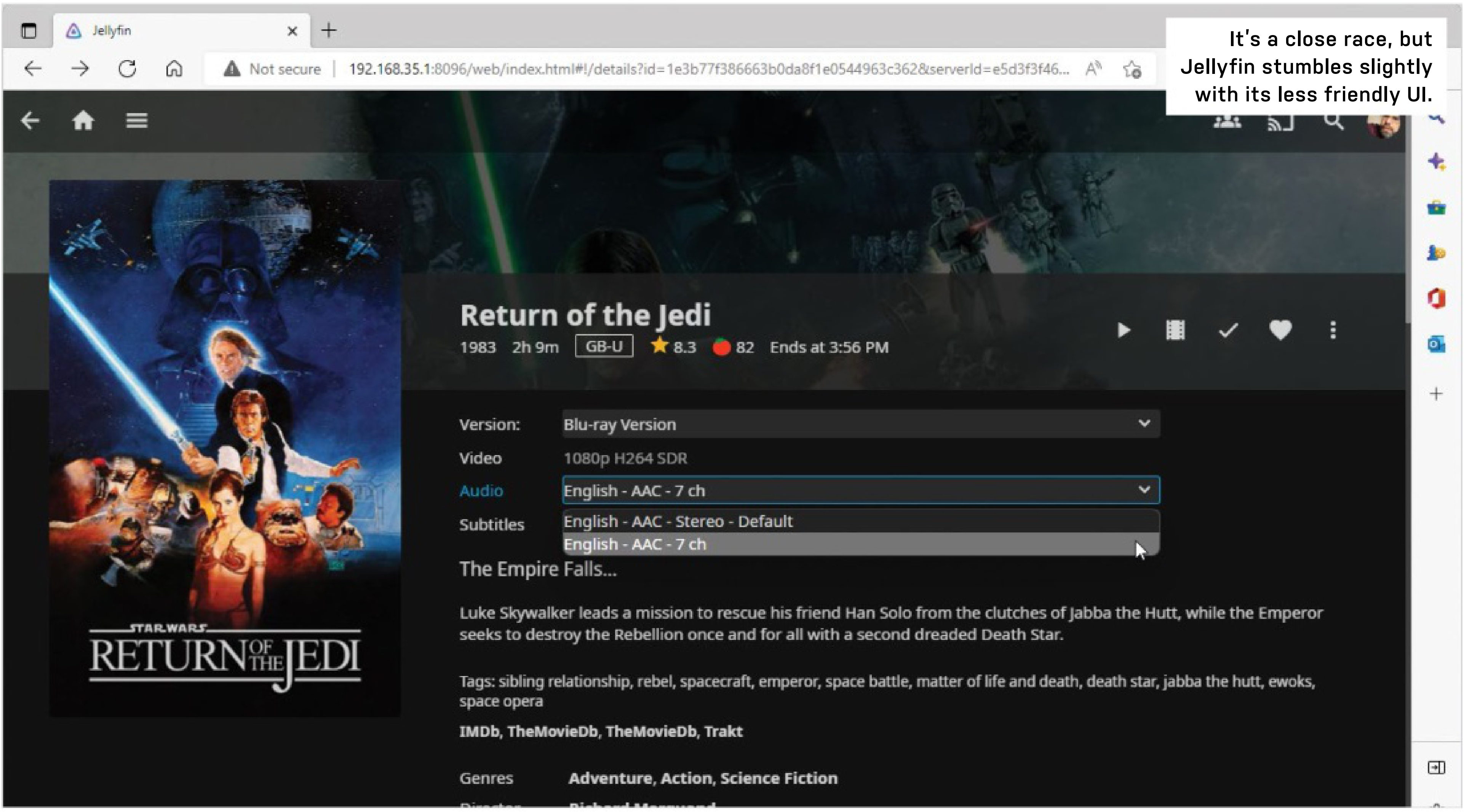
How you store, organize and access your media is a crucial part of any media server, and both apps do an excellent job. If your media is named and stored in the correct folder structure, then your library is populated with rich information providing detailed descriptions down to an episodic level for TV series, along with artwork and additional information about actors, ratings, and so on.

ABOVE AND BEYOND

Both apps do an excellent job of presenting this library in an attractive and easy-to-navigate view across their various clients. And they go above and beyond with support for incorporating extras, such as documentaries, deleted scenes, trailers, and so on, into your library too. Here, Plex currently has the edge, and not just with Plex Pass subscribers who will find a range of extras have been made available online to stream alongside any locally curated ones.

One example of the cut and thrust of development between the two can be found in their TV extras. Initially, users were compelled to house all specials, including featurettes and deleted scenes, within a single Specials folder. Jellyfin 10.8 raised the stakes by allowing specials to be embedded at the season level, while Plex went down the route of embedding extras at the episodic level (perfect

© P.EX



It's a close race, but Jellyfin stumbles slightly with its less friendly UI.

Jellyfin

192.168.35.1:8096/web/index.html#!/details?id=1e3b77f386663b0da8f1e0544963c362&serverId=e5d3f3f46...

Return of the Jedi

1983 2h 9m GB-U ★ 8.3 82 Ends at 3:56 PM

Version: Blu-ray Version

Video 1080p H264 SDR

Audio English - AAC - 7 ch

Subtitles English - AAC - Stereo - Default

English - AAC - 7 ch

The Empire Falls...

Luke Skywalker leads a mission to rescue his friend Han Solo from the clutches of Jabba the Hutt, while the Emperor seeks to destroy the Rebellion once and for all with a second dreaded Death Star.

Tags: sibling relationship, rebel, spacecraft, emperor, space battle, matter of life and death, death star, jabba the hutt, ewoks, space opera

IMDb, TheMovieDb, TheMovieDb, Trakt

Genres Adventure, Action, Science Fiction

for deleted scenes, for example). Plex has subsequently added season-level support, while Jellyfin's Github reveals that it is developing support for episode-based features on the Plex model.

This level of detail may seem like overkill, but for true media connoisseurs, they are essential improvements that highlight both apps' commitment to their core offerings. That's important, as the majority of Plex's development over the past few years appears to have been in widening its remit.

BELLS AND WHISTLES

Beyond their core functionality, what else is on offer? Both services can be connected to a TV tuner and used to stream live TV (perfect when away from home) as well as function as a DVR, with recordings placed in your library. Plex users require a Plex Pass to access the DVR. Both Jellyfin and Plex also support hardware-accelerated streaming and transcoding, to reduce the load on your CPU. Sadly for Plex users, hardware transcoding is another option restricted to Plex Pass users.

These features sit comfortably with existing functionality, but it's here where the two apps start to diverge once again. Jellyfin continues for the most part to focus on its main remit, but through a range of plugin models, it has made it possible to add extras, for example, the Jellyfin Bookshelf Plugin adds support for audiobooks, eBooks, and digital comics.

Plex has found itself trying to find other ways to monetize the service, specifically by augmenting your existing content with others. It offers its own 'free' ad-supported streaming movie and TV channels to sit your existing content, while a recent collaboration with Tidal aims to encourage users to augment their existing music libraries with streaming content via another subscription.

When you strip away the extras, though, you're left with two apps that do pretty much the same thing, and they both do it well. At this point, the only way to really differentiate them is through their user interfaces, and it's here that Plex edges ahead. Take the implementation of subtitles, for example. Plex has built-in support for uploading and searching online for subtitles to integrate into your movies as you watch them—it's simple to access and works well.

In contrast, you will need to install a separate plugin (OpenSubtitles) in Jellyfin, link it to an account, and then configure your subtitles before watching the movie. Fiddly stuff is made even harder thanks to gaps in its documentation. That extra attention to user-friendliness and detail is why Plex wins by a nose in our head-to-head comparison.

Jellyfin is an excellent tool and more than holds its own with the free version of Plex, given it contains many features restricted to Plex Pass subscribers. It's also more configurable and scores highly with its direct server setup. But if you're happy to invest, then Plex's more polished look and wider device support give it the edge. For now, at least. **–NICK PEERS**

VERDICT
9
KICK ASS!

Plex

⊞ **OSCAR WINNER** Packed with features; easy to navigate and use.

⊟ **RAZZIE WINNER** Key features locked behind a paywall; focus drifting from core features.

RECOMMENDED SPECS Intel Core i7 3.2GHz CPU for 4K transcoding, 4GB RAM, Linux or Windows.

$Free, Plex Pass costs $5 (month), $40 (year) or $150 (lifetime), www.plex.tv

VERDICT
8

Jellyfin 10.8

⊞ **MASTER THESPIAN** Powerful and configurable; completely free.

⊟ **OLD HAM** A little rough around the edges; difficult to configure in places.

RECOMMENDED SPECS Multi-core CPU with GPU acceleration, 4GB RAM, Linux or Windows.

$Free, https://jellyfin.org/

© JELLYFIN

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> TVs as Monitors
> Sound Card Salute
> Jarring Jargon

The Best Thing On TV

I'd like to respond to R. Kleinhaus's letter in the August 2022 issue ('Monitor Money'), regarding a new monitor recommendation. The point was made that the writer doesn't need a monitor that can accommodate competitive gaming. In that case, I would suggest getting an HDMI 2.1 4K TV.

I've been using a 48-inch LG OLED48CXPUB for about a year and I absolutely love it! There's no noticeable screen lag, it has frame sync, HDR, 4K resolution, 120Hz, pure blacks... the list goes on.

The one thing I didn't catch when purchasing it is that it can only do 4K at 60Hz, not the full 120Hz. You need to set your output resolution to 2,560x1,440 to get 120Hz. That's fine because it still looks fabulous, even on a 48-inch screen at a close-up distance. I hear LG's newer OLED models are even better. **–R. Peterson**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS:
Mr. Peterson makes an excellent point, and one that I'm sorry I didn't cover in my original response to this question—especially because I personally have the LG OLED65BX model myself as my main television. As you mention, the 48-inch model is a particularly popular model for PC use, including some of my own friends who swear by the setup.

As you say in your letter, the 'X' or 10th-generation sets that you and I have do not support 4K at 120Hz. This isn't particularly an issue for me, as even with an RTX 3090 graphics card, there aren't many games I'm going to be playing at such high resolutions and frame rates.

The newer 'C1' and 'G1' sets from LG do support higher refresh rates, however, so if that's important to you, make sure you get one of the newer models. As you say though, games still look fantastic, even at 1440p on this display.

With a new 55-inch PC monitor coming in from Samsung (see our Odyssey Ark hands-on on page 73), maybe now is the time to go big or go home when it comes to your PC display.

Are any of you using a large or novel PC monitor? Let me know at the usual email address.

Falling on Deaf Ears

I started playing PC games in the early 2000s when my friend built me a PC to get the job done. At first, I used the stock sound on the computer's motherboard, but it would get flaky playing *World War II Online: Blitzkrieg* and *America's Army*. So I bought my first soundcard, a Creative Labs Audigy, which provided a drastic change to my gaming experience.

A year or so later, I picked up my first set of Zalman surround-sound headphones, which offered a huge change—5.1 analog sound was awesome.

After going through numerous Creative Labs cards, moving from 5.1 to 7.1 channel sound, I now use a pair of Astro A50 headphones with the sound coming from a Creative Labs card via the digital TOSLINK out.

It seems that 90 percent of headsets nowadays are virtual and 7.1 USB, so what is the point of a sound card anymore, if you're going to use modern headsets? I think Astro and maybe Sennheiser are the only ones left that can take advantage of a sound card.

I hate to give up on sound cards, but maybe it's finally time. Am I missing something? Do some of these USB headsets have pass-throughs that will use the soundcard's drivers? **–B. Zab**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS:
PC sound cards are far from dead, but you're right, they aren't the necessity they once were. In fact, I had to look over at my personal computer's Gigabyte Z490 Aorus Elite AC to remind myself what audio outputs it has. I use them so infrequently because both my speakers and headset use USB.

However, if you're really serious about audio, whether that's for gaming or listening to music on high-quality speakers or

↘ submit your questions to: editor@maximumpc.com headphones, then you'll get a lot of value out of a sound card, with newer ones also providing a high-quality DAC (digital-to-analog converter) and amplifier.

SteelSeries (GameDAC, $130) and EPOS (GSX 300, $70, or GSX 1000, $200) are the leaders here, so not only you're getting the best audio quality around, but as they come with a physical controller, you have more granular control of your audio without having to tinker in the Windows settings.

You also mention your love of surround sound, so I thought it worth mentioning the JBL Quantum 910 headphones that I saw at Gamescom in Germany this month (see page 55). They feature JBL's QuantumSPHERE360, QuantumSPATIAL 360, and Quantum SURROUND technology, allowing for highly precise spatial audio and head tracking.

They're also wireless and cost $250, which is a pretty reasonable price for all that tech. They might offer you the kind of aural leap forward you've been craving for the last few years. However, I'd advise you head to a store where you can check them out first, just in case virtual surround isn't your bag.

Bright Ideas

Your 'how-to' article on maintaining graphics cards (September 2022) may be the single most useful article I've ever seen in your magazine. Thank you so much, this knowledge alone more than covers my decade-or-so of subscription payments.

However, I must admit to having felt completely out at sea while reading the following sentence in your review of the Asus ROG Flow X16 laptop (September 2022): "But do they crank out 1,100 nits of brightness, support HDR 1000, deliver 100 percent coverage of DCI-P3 and pack 512 mini-LED dimming zones?"

The SteelSeries GameDAC is worth looking at for audiophiles who play games or listen to music on their PC.

© STEELSERIES

Not being versed in the mysteries of audio-visual science, I couldn't make head nor tails out of that sentence. What exactly is 'DCI-P3' and how does it benefit from "100 percent coverage"? What are "HDR 1000" and a 'mini-LED dimming zone'? And pray tell, what on earth is a 'nit of brightness' and in what way does it matter how many of them there are?

Doubtless, I'm not the only reader who was left scratching his head after running into that sentence. Perhaps you might offer a glossary of A/V terms that are likely to come up in your pages, or else prepare a feature explaining some of this technical vocabulary to us nits who don't have enough brightness.

–J. Amador

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS:
It's almost like my 18 years of reviewing TVs and monitors have prepared me for this very moment!

First of all, apologies for any confusion caused by this sentence, or any other sentence, in the magazine that causes bewilderment. It's a constant balance for us—just this morning, I was in an editorial meeting where we discussed having the name 'TSMC' on the cover and whether people would know what that stands for or what the company does. I went up to bat for *Maximum PC* readers and said most would know, but I'd love to know if that's true or not!

But I digress. When it comes to monitors, there are lots of terms to learn, some of which are relevant and some aren't depending on what you're doing. For example, DCI-P3 is a color space used in theatrical motion picture distribution, so if you're a video editor or watching a lot of video content, it's an important consideration.

'Nits' is a term that refers to the brightness of the screen. It's too technical to explain in full here, but for context, the new iPhone 14 Pro is the brightest mobile screen at 2,000 nits, which is important as it helps you view the screen in daylight. It's less important on a monitor that will be used indoors, but 1,100 nits is relatively good compared with other monitors.

Finally, HDR levels are useful as a comparative tool—most gaming monitors boast HDR400 or HDR600, but many gamers (myself included) don't turn HDR on in games as it's not really worth it at those levels. The Asus laptop has a much better HDR spec (it also uses an OLED panel), so it's worth turning on and enjoying deeper blacks and better color reproduction.

I hope this helps. And apologies if it was over-technical. I'd love my next monitor to be an OLED screen, so I was salivating a bit when reading how good the Asus laptop was!

Laptop Lover

I was reading through some back issues when I saw Jeremy Laird's article saying laptops suck (February 2022). I agree that they do for pure gaming and content creation next to a *Maximum PC*-built desktop, but it's a different market and usage model. I can't carry my desktop onto a plane and set it up in my airline seat, for example.

I travel a lot for work and I've been on the quest for the perfect laptop for around 25 years. My first model was a Sony Vaio with floppy disks and swappable batteries. Since then, I've used everything from a 17-inch desktop replacement to a 13-inch road warrior and I've found you always have to give something up or make trade-offs.

My current travel buddy is an Asus ROG Zephyrus G14 with the Radeon RX 6800S and an 8TB SSD I slapped in myself since my game library is so big it has started to gain its own consciousness.

I go for integrated graphics so I can power it on an airplane with the in-seat plug while I play simple strategy games. It's convenient, although it still runs hot sadly. Like I say, always a trade-off.

–C. Chisum Chad

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS:
I suspect Jeremy knew it may be a controversial piece when he wrote it, however, it turns out that his article from February has been our most debated of the year!

I've already written a counter-point (April 2022) and I stand by what I said—I love having a gaming laptop and would probably give up my mobile phone before ditching my portable gaming machine. I noticed it this month especially, as the SSD drive in my Lenovo Legion 5i Pro broke and I had to make a warranty claim—not having the use of it has been a real pain.

I haven't used the machine you have, but I was looking at purchasing one last year. If you need ultra-portability and the ability to game, it looks like the best option, so I'm glad you enjoy using it. ⏻

THE BUILDS

THIS MONTH'S STREET PRICES...

BUDGET

CREATING A BUDGET build for under $1K may not result in a top-end machine, but it does force you to think about how to spend your money wisely. With new AMD and Intel chips coming towards the end of the year, we hope this will reduce the price of the current budget-end CPUs, freeing some cash to spend elsewhere.

We're not quite there yet, though. Our AMD machine sees two changes this time. First, we save $30 by swapping from ASRock to MSI for our GPU choice. Out goes the 6650 XT Challenger D OC and in comes the 6650XT MECH 2X OC. We've managed to maintain an OC card for less money, so it makes sense. We can't complain about out-of-the-box overclocking for this price.

By changing our previous Corsair Vengeance LPX CL16 to PNY's XLR8 Gaming EPIC-X RGB we also get a splash of color in our AMD machine. Costing an extra $2 and performing similarly, it's a cheap upgrade. A price hike in our previous HDD meant that we had to bring in Seagate's SkyHawk Surveillance 7200 HDD to replace the awkwardly-named Seagate ST4000NM0024. This change is made on both the AMD PC and the Intel one.

Over on the Intel build, we're greeted by a few savings. Our motherboard drops down in price to $109 from $120. We've spared $10 on our GPU by shrinking it down to an ITX form factor card. The MSI RTX 3060 VENTUS 3X OC is replaced by another MSI RTX 3060, the AERO ITX OC. It's an interesting choice but also retains the same power as the GPU it knocks off the podium.

As well as bringing the Seagate SkyHawk Surveillance 7200 HDD into the Intel machine, we also add the splash of color provided by the RAM from the AMD budget build. This PNY XLR8 Gaming EPIC-X RGB RAM, like on the AMD machine, replaces a similarly speedy memory but adds the RGB element into the case for a $5 saving. Overall, there haven't been too many changes, just a few subtle swaps to keep both builds fresh.

AMD INGREDIENTS

PART			PRICE
Case	Corsair 4000D Airflow		$95
PSU	550W Asus TUF Gaming 80+ Bronze		$49
Mobo	MSI B550M PRO-VDH WiFi AM4		$119
CPU	AMD Ryzen 5 5600X		$195
GPU	MSI Radeon RX 6650 XT MECH 2X OC 8GB	NEW	$330
RAM	16GB (2 x 8GB) PNY XLR8 Gaming EPIC-X RGB @ 3600MHz	NEW	$70
SSD	500GB MSI Spatium M450 PCIe 4.0 M.2 SSD		$62
HDD	4TB Seagate SkyHawk Surveillance 7200 HDD	NEW	$88
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32
Approximate Price:			**$1,040**

INTEL INGREDIENTS

PART			PRICE
Case	Corsair 4000D Airflow		$95
PSU	550W XPG Pylon 80+ Bronze		$70
Mobo	ASRock B660 Pro RS LGA 1700		$109
CPU	Intel Core i5-12600		$230
GPU	MSI GeForce RTX 3060 AERO ITX OC 12GB	NEW	$370
RAM	16GB (2 x 8GB) PNY XLR8 Gaming EPIC-X RGB @ 3600MHz	NEW	$70
SSD	500GB MSI Spatium M450 PCIe 4.0 M.2 SSD		$62
HDD	4TB Seagate SkyHawk Surveillance 7200 HDD	NEW	$88
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32
Approximate Price:			**$1,126**

MID-RANGE

AT AROUND $500-600 more than the budget PCs, our mid-range offerings from both AMD and Intel allow us the freedom to improve our gaming capabilities by some margin. Here, we will be aiming for a smooth 1440p experience. Starting with our AMD mid-range build, there aren't too many changes this time around.

Prices have stayed pretty much the same as the previous month's builds so, again, we're left waiting for the new chips to come out to hopefully see a drop in the current-gen processor prices. Already, our AMD Ryzen 7 5800X can be picked up for around $50 less than before. This gives us even more reason to keep this 8-core CPU, although we didn't need much persuading.

Alongside this processor is the ASRock Radeon RX 6800 XT Phantom Gaming D OC card. Overclocked from the get-go, this mighty GPU is still available for $640. We've introduced the HDDs from the budget machines here—we previously had the Seagate ST4000NM0024, but these hiked in price so Seagate's SkyHawk Surveillance 7200 HDD replaced it in both mid-range builds.

We also decided to upgrade from 500GB capacity to 1TB. For an extra $30 on the Intel side, we brought in the 1TB ADATA XPG GAMMIX S70 that we featured in our build this issue. With snappy performance, it's great value at this price. For the AMD machine, a 1TB Crucial P5 SSD replaces the previous 500GB Western Digital Black SN850. It's $45 more expensive, but we get a similar performance and double the capacity.

Another change on both builds is the introduction of the NZXT C750 80+ Gold PSU. Thanks to an Amazon sale, we can bring this in for now. It replaces the EVGA SuperNOVA 750 GT 80+ Gold which was previously on sale but has now gone back up in price. Lastly, another sale has ended for our MSI GeForce RTX 3070 VENTUS 2X OC GPU. Annoyingly, this has increased by $70 but that's still a decent price for an OC RTX 3070 graphics card.

AMD INGREDIENTS

PART			PRICE
Case	NZXT H7 Flow		$130
PSU	750W NZXT C750 80+ Gold	NEW	$80
Mobo	ASRock X570 Steel Legend AM4		$145
CPU	AMD Ryzen 7 5800X		$245
Cooler	Cooler Master MASTERLIQUID ML240L RGB V2		$75
GPU	ASRock Radeon RX 6800 XT Phantom Gaming D 16GB		$640
RAM	32GB (2 x 16GB) Corsair Vengeance RGB RT CL16 @ 3600MHz		$133
SSD	1TB Crucial P5 NVME M.2 PCIe 4.0	NEW	$102
HDD	4TB Seagate SkyHawk Surveillance 7200	NEW	$87
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32

Approximate Price: $1,669

INTEL INGREDIENTS

PART			PRICE
Case	NZXT H7 Flow		$130
PSU	750W NZXT C750 80+ Gold	NEW	$80
Mobo	ASRock Z690 Pro RS LGA 1700		$160
CPU	Intel Core i7-12700F		$310
Cooler	Cooler Master MASTERLIQUID ML240L RGB V2		$75
GPU	MSI GeForce RTX 3070 VENTUS 2X OC 8GB		$630
RAM	32GB (2 x 16GB) Corsair Vengeance RGB RT CL16 @ 3600MHz		$138
SSD	1TB ADATA XPG GAMMIX S70 M.2 PCIe 4.0	NEW	$109
HDD	4TB Seagate SkyHawk Surveillance 7200 HDD	NEW	$87
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32

Approximate Price: $1,751

WE DON'T WANT TO repeat ourselves too much, but our turbo machines are only going to get more exciting when the new CPUs and GPUs eventually start to roll out over the next few issues. Of course, these new parts aren't going to void the current processors and graphic cards we have in place because regardless of what's coming, you can still get some monstrous performance from these turbo builds. There's plenty of life left in them yet.

We have two changes on the turbo AMD build, starting with a motherboard swap. We say goodbye to the previous ASRock X570 Taichi and replace it with the Gigabyte X570 GAMING X mobo. At just over $200, it has all that we'll need for future-proofing and performance at this price point. Another change is to replace both our SSDs in our Turbo models. Western Digital's SN850 has proved to be a super-snappy SSD that we have used multiple times in our own builds as well as this segment of the magazine. As soon as the SN850X was released (reviewed page 89), which is a sharper offering at a similar price, we knew we wanted to include it. Sequential read speeds of 7300MBps and write speeds of 6600MBps make this one hot SSD.

That's all for the AMD machine, the ASRock OC Formula Radeon RX 6950 XT GPU is still priced at $999, so we kept that in place. Also, the CPU that runs this ship, the AMD Ryzen 9 5950X, is still a mighty fine processor only rising by $3 from last month, which we can't moan about. As for the Intel machine, other than the SN850X coming in, we upgraded our PSU to a 1000W unit. Specifically, the 1000W Corsair RMx 80+ Gold should cover the extensive power draw from both our Intel Core i9-12900K and the Gigabyte GeForce RTX 3090 Ti Gaming GAMING OC GPU.

There were no real price increases to worry about this issue. So, we are excited for the new components to come along in the not-too-distant future. This should spice up our machines either with some big price difference or some new components.

AMD INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$190
PSU	850W EVGA SuperNova P6 80+ Platinum	$115
Mobo	Gigabyte X570 GAMING X ATX AM4 **NEW**	$206
CPU	AMD Ryzen 9 5950X	$548
Cooler	NZXT Kraken X73 73.11 CFM 360mm	$155
GPU	ASRock OC Formula Radeon RX 6950 XT 16GB	$999
RAM	64GB (2 x 32GB) G.Skill Trident Z RGB DDR4 @ 4000MHz CL18	$280
SSD	1TB WD Black SN850X M.2 PCIe 4.0 **NEW**	$135
HDD	6TB WD Blue 5400 HDD	$99
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32

Approximate Price: $2,759

INTEL INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$190
PSU	1000W Corsair RMx 80+ Gold **NEW**	$140
Mobo	Asus TUF GAMING Z690-PLUS WIFI DDR5 LGA 1700	$270
CPU	Intel Core i9-12900K	$570
Cooler	NZXT Kraken X73 73.11 CFM 360mm	$155
GPU	Gigabyte GeForce RTX 3090 Ti Gaming GAMING OC 24GB	$1,400
RAM	64GB (2 x 32GB) G.Skill Ripjaws S5 DDR5 @ 5600MHz	$389
SSD	1TB WD Black SN850X M.2 PCIe 4.0 **NEW**	$135
HDD	6TB WD Blue 5400 HDD	$99
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32

Approximate Price: $3,380

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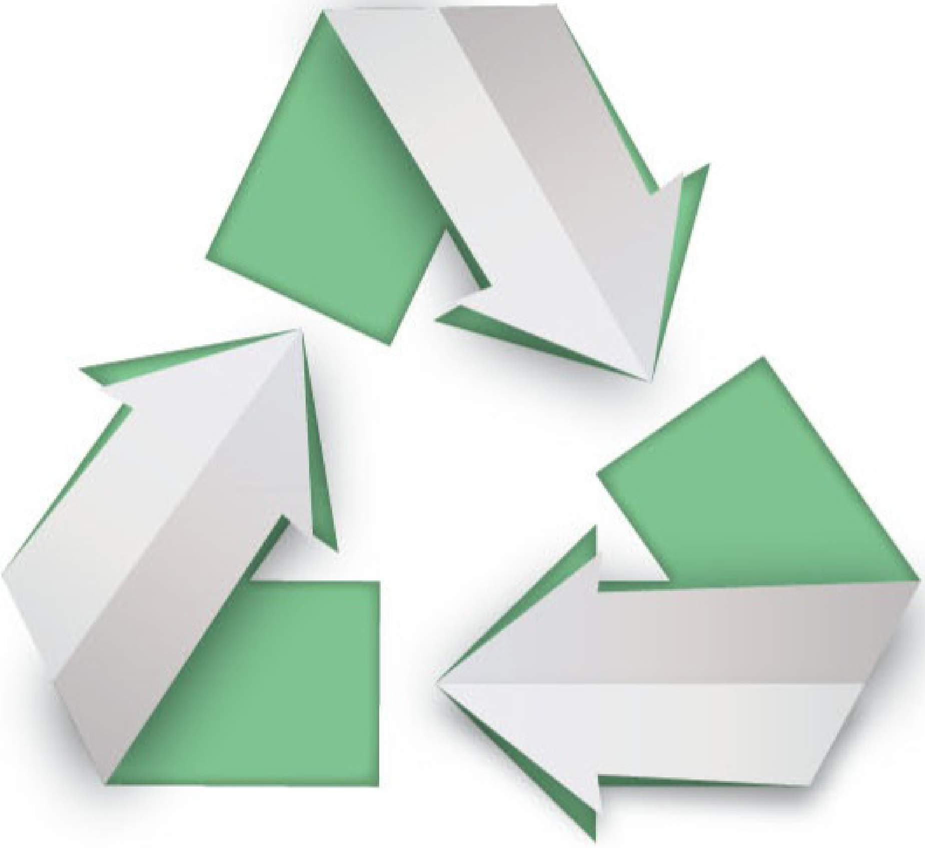

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